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**THE EFFECTS OF SONG SINGING ON IMPROVEMENTS  
IN AFFECTIVE INTONATION OF PEOPLE WITH  
TRAUMATIC BRAIN INJURY**

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## ABSTRACT

This study examined the effects of a song-singing program on the affective speaking intonation of traumatically brain-injured people who presented with monotonal voices. Four subjects received 15 sessions of music therapy comprising the singing of three subject-preferred songs. The variables of: speaking fundamental frequency, standardised variability and slope, pitch range, pitch-matching accuracy and mood were analysed pre and post-session. The audio data was analysed using Multi-speech™ with real-time pitch module. A key phrase selected from songs used in the subjects' sessions was also analysed to determine pitch-matching accuracy and later compared with the intervals in the pitch-matching exercise. The visual analogue mood scales were assessed as per standardised procedure.

Results suggest that long-term improvements in affective intonation are evident, especially in fundamental frequency, however the response direction and degree of change are idiosyncratic. Immediate treatment effects (pre/post-session differences) were in the direction contrary to that expected (negative). Fatigue is suggested as one explanation for this result, particularly as fatigue was reported in the visual analogue mood scale. Vocal range improved over time in all four subjects and was positively correlated with all three intonation components, particularly the standardised variability score. High variability in responses was evident in the interval tasks. The mood scale responses were also variable, and interpretations of therapy effects on mood should be treated with caution. Negative correlations (that opposite to expected) were found between the mood scales and intonation variables suggesting that as subjects reported becoming more emotional, they became more monotonal, had flatter slope measures and a lower fundamental frequency. Subjects sang intervals more accurately when they were in a song than when presented in isolation.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Background of thesis

The complex nature of the voice, its propensity to being affected by brain injury and its responsiveness to music therapy treatment has always fascinated me during my work as a music therapy clinician. While working in the only specialist rehabilitation facility for brain-injured people in the southern hemisphere, I was fortunate to be provided with a continuous stream of brain-injured clients presenting with a range of impairments in communicative, cognitive, behavioural, physical and psychosocial functioning. The hospital treatment philosophy promotes inter-disciplinary teamwork where common goals are shared amongst the different disciplines. In finding a place for music therapy to mesh within this framework (Lee and Baker, 1997), I found myself working closely alongside the speech pathologists and taking an active role in promoting clients' communicative potentials. I have witnessed how important it is for some clients not only to communicate verbally but also to be able to do this effectively. Effective communication not only requires the ability to clearly articulate words but also includes the appropriate and effective use of the expressive qualities of the voice – pitch, volume etc. I was often asked to devise music therapy programs to help with phonation, breath control and pitch control in people with voice disorders and these programs had positive results. I was drawn to this work because I considered working with the voice – the human body's own instrument – rewarding and at the same time fascinating. This culminated with my personal need to investigate this phenomenon more closely. More specifically, my study investigated whether singing songs could facilitate improvements in the speaking intonation of people with brain injury, and to explore what factors might be involved in this process.

## 1.2 Intonation concepts and treatment trends

Intonation, one of three components of prosody - stress patterning, intonation and rhythm - produces the melodic aspects of verbal communication (Yorkston, Beukelman & Bell, 1987). It helps the listener to indicate whether the phrase is a question or statement, which word in the sentence is the most important and what the mood of the speaker is (Yorkston et al., 1987). Not only does it contribute to the accurate communication of a thought and feeling but it also contributes to the formation of identity (Newham, 1999). The sound of people's voices serves as markers that affirm and reinforce who they are. For people, there is a complex set of changing sounds that identifies or distinguishes them from all others, thus giving them their identity (Newham, 1999). These patterns, which are unique to the individual, form their voiceprint (akin to a fingerprint) (Pittman, 1994).

Following brain injury, the client may present with poor speaking intonation even in the absence of other major impairments (Aronson, 1990). For those displaying this impairment, their voice lacks expressive capabilities, and they may be unable to accurately express the feelings or intentions attached to their verbal responses. They present with a reduced vocal pitch range, and their voice can sound monotonous, flat, and uninteresting to the listener. When this occurs, there is an increased risk that communication will break down. While this may seem a relatively minor impairment in comparison to other more debilitating communication impairments such as dysarthria, dyspraxia, and aphasia, inevitably it jeopardizes the speakers' development and maintenance of relationships with others and may reduce their possibility for rejoining the workforce (Aronson, 1979 cited Aronson, 1990, p.168; Benninger, Ahuja, Gardner, & Grywalski, 1998). In addition to the potential breakdown in communication with others, these people are also experiencing losses or changes in their identities. They have "lost" the voice that had belonged to them up to this traumatic experience in their life (as well as dealing with the other losses associated with neurological trauma). All these problems may lead to depression, setting off a whole new string of problems (Aronson, 1990).

Speech pathology techniques that specifically target this clinical condition have been infrequently cited in the literature, and most programs documented describe improvements in intonation secondary to the treatment of another area of verbal rehabilitation (Hargrove & McGarr, 1994). Perhaps this is because people might be researching the more debilitating conditions – aphasia, dyspraxia and dysarthria – rather



than focusing on what might be considered to be merely a cosmetic problem. Furthermore, financial restrictions in the health sector limit the potential for developing specialised techniques for improving intonation. What money is available is directed towards the treatment of these other more debilitating communication impairments, and consequently research on intonation that arises out of clinical practice may be limited. Similarly, when considering voice disorders in general, other voice disorders seem to have been given priority in the research field. For example, the treatment of voice disorders in singers and actors has attracted a great deal of attention in the research literature, which is not surprising given it is a health issue that directly affects people's careers (Blaylock, 1999; Broadus-Lawrence, Treole, McCabe, Allen, & Toppin, 2000; Hogikyan, Appel, Guinn, & Haxer, 1999; Rosen & Murry, 2000; Sataloff, 2000; Surow & Lovetri, 2000). In addition, much of the existing research is more at a diagnostic level, which does not necessarily assist people with voice disorders to overcome them (Mishra, Rosen, & Murry, 2000a; 2000b; Phyland, Oates, & Greenwood, 1999; Rosen & Murry, 2000). These factors point strongly towards the need for developing techniques that specifically target the treatment of intonation impairments.

With regard to music therapy research in this area, there is only a handful of studies and case reports which directly focus on intonation for people with neurological damage (Cohen, 1992: 1995; Cohen & Masse, 1993; Kennelly, Hamilton, & Cross, 2001; Livingston, 1996; Lucia, 1987). These have focused specifically on changes to vocal control such as the fundamental frequency, fundamental frequency variability and fundamental frequency range of the voice. However, no studies have examined the effect of music therapy on the speed and degree of frequency changes within a person's conversation, otherwise known as slope. Vocal contours can have steep slopes where fast and large variations in frequency occur, or they can have flatter slopes where there are smaller and much slower changes in pitch.

Another aspect not addressed in the music therapy literature is whether improvements in fundamental frequency, fundamental frequency range and slope actually transfer to improvements in the normality of the intonation patterns. It is possible that people may use a greater range of frequencies while they speak but this does not necessarily mean that the shape of the intonation contours match their intended meanings. There is certainly a need for this to be established in research if music therapy programs are to be viewed by other health professions as generating functional outcomes. Further, these studies do not document the process of recovery – the speed and/or extent of

recovery, nor the specific aspects of intonation that improved the fastest and to the greatest degree. Perhaps rising contours improve more quickly and/or to a greater degree than falling contours (or vice versa). In addition, there are no studies determining whether changes in speaking pitch height, or variability of pitch and slope, mirror or differ from changes in singing ability. By this I am suggesting that there may be some correlation in the changes made between the two areas of function.

Much of the music therapy research that does exist has explained their findings from neurological perspectives. Here, recovery has been understood as a product of either reactivating or reconnecting temporarily inhibited neural areas or developing new ones (Cohen, 1992; 1995; Cohen & Masee, 1993; Lucia, 1987). While I support the idea that neurological processes are active in facilitating these changes, my experience in working with this population lead me to believe that this was not the only process responsible for facilitating improvement. I observed that physiological and emotional changes occurring during music therapy seemed to directly or indirectly facilitate improvements in intonation – either temporarily or more permanently. This phenomena has not been explored in studies of people with neurological damage although there has been anecdotal reporting showing that the voices of depressed people become less monotonous following music therapy sessions (Magee, 1999a).

### **1.3 Case vignette and development of theoretical position**

In order to explain the context and roots of this investigation, a vignette selected from my own clinical work has been included. The clinical work, and the emerging changes in my client's self-esteem and confidence which corresponded with improvements in vocal control, challenged me to consider broader explanations for improvements in all clients' vocal capacities following participation in my music therapy programs. The client, Leo<sup>1</sup>, was a 19-year-old man who had received a mild-moderate unilateral brain injury following a motorbike accident in 1999. Following discharge from an intensive three-week inpatient rehabilitation program, Leo attended a music therapy program, designed to help him redevelop a greater range of vocally expressive intonation patterns, and improve his voice volume. Leo reported that although he could verbally communicate with others in his

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<sup>1</sup> A pseudonym has been used to protect the identity of the client.

workplace, family life and social circle, he was not confident to do so. He stated that he was aware of the changes in his voice and that other people (family and friends) had also commented on these changes. I understood Leo's comments as his realization of a change in his identity, a vocal identity he was not comfortable with and wanted to change.

On assessment, Leo spoke in a monotone voice and was only able to sustain a single, quiet, tense vocal sound for six seconds. During structured vocal exercises, he was able to produce a pitch range of up to a major 3<sup>rd</sup> (although he found this difficult). He participated enthusiastically in a variety of singing exercises, song singing and imitating given vocal patterns during the assessment. When Leo sang songs, I noticed that he sang them using pitch ranges in excess of a major 3<sup>rd</sup>, and although his pitch control was still poor, he was generally able to follow the overall melodic contour of the song. At the end of the session I retested Leo and noticed that his pitch range was unchanged (major 3<sup>rd</sup>). However, I perceived that his intonation was less monotonal.

Leo then participated in an eight-session music therapy program comprising discussions, vocal exercises and song singing. Leo made some noticeable improvements in his vocal ability - he was able to sustain a single note for up to 14 seconds and able to produce a vocal range of 18 note pitches (during singing and vocal tasks). Although difficult to assess, I believe that during conversations, Leo was utilising a pitch range of about a perfect 4<sup>th</sup>. However, my lack of rigorous measurement tools prevented an assessment as to the extent of these improvements. What was important was that Leo gained confidence using his voice as evidenced by an increase in the number and length of time he initiated and engaged in conversations with people.

This short case study stimulated questions about whether clients became more capable of expressing intended meaning in their intonation following participation in a music therapy program, or whether they were merely less monotonal. Another question, which evolved from this case study, concerns why the singing program appeared so effective in improving the vocal expressiveness of Leo. When considering this, several explanations were conceptualised. First, participating in music therapy may allow the practice of vocally expressing a range of feelings, which are inherent in different songs, thereby helping maximize the expressive potential of the voice.

Alternatively, perhaps the music functioned as a concrete melodic model for Leo to follow (a concreteness absent in speaking intonation), with the more exaggerated, predictable and precisely placed melodic contours of songs-melodies easier to follow vocally than that of the reduced melodic contour of prepositional speech.

Another possibility is that the participation in singing facilitates release of emotional, physical and psychological tension, thereby freeing the voice of constraints (Aronson, 1990; Bunch, 1997; Moncur and Brackett, 1974; Newham, 1999; Pittman, 1994; Stengel and Strauch, 2000). This might explain the described immediate change observed in Leo's assessment session, these changes being unlikely to occur in such a short period of time (20 minutes) from purely neurological processes. Such tension is predictable given the adjustment issues related to the sudden acquisition of disability, change in identity, and anxiety about therapy outcomes.

Leo's improved intonation may have been the result of a change in mood, given that some research has shown that people who are clinically depressed use a limited vocal range when they speak (Alpert, Pouget, & Silva, 2001; Frolov, Milovanova, Lazarev, & Mekhedova, 1999; Garcia-Toro, Talavera, Saiz-Ruiz, & Gonzalez, 2000; Kuny & Stassen, 1995). Perhaps singing increased positive mood states within Leo, and this was reflected in a more dynamic intonation style. The fact that Leo's vocal pitch range did not change between pre and post assessment and yet appeared less *monotonal* in his speech following the session strongly supports this possibility.

Finally, the activation of a neurological process as a consequence of participation in a music experience could explain Leo's responses. The brain is a complex organ, and although there is strong support for neuroplastic processes being activated from focused therapy (Kolb & Gibb, 1999; Musso, Weiller, Kiebel, Müller, Bülau, & Rijntjes, 1999), such processes have not been studied in music therapy to date. Similarly singing has been shown to activate certain regions of the brain which further supports this argument (Gunji et al., 2003; Levy, Granst & Bentin, 2001; Perry et al., 1999). Given the evidence of brain recovery processes, there could be neurological processes occurring which might stimulate or reawaken neural pathways. Singing may have enabled Leo to engage these pathways and consequently, to use a greater range of note pitches in speaking intonation. At this point, this idea is purely speculative, and there has been no evidence to either support or reject this possible explanation.

In my opinion, it is highly likely that a combination of these perspectives explain Leo's improvements. Neurological models emphasise that a person responds to music stimuli based on what cortical areas remain functionally intact following neurological damage. These models consider the damaged brain as a "thing" that has the potential to be accessed through the different components of music (such as rhythm, melody, pitch etc), these corresponding with various cortical locales (for example Alcock, Wade, Anslow, &

Passingham, 2000; Griffiths, 2001; Liégeois-Chaurel, Peretz, Babäi, Laguitton, & Chauvel, 1998; Parsons, 2001; Peretz, Blood, Penhune, & Zatorre, 2001; Samson & Zatorre, 1992; Tecchio, Salustri, Thaut, Pasqaletti, & Rossini, 2000). Further, much of the research from neuromusicology, whilst providing important findings concerning the way people respond to music, seems to only look at neuromusical processes at a diagnostic level. It does not provide clear links as to how these findings may be useful to music therapy theory and practice. Only a few sources implicate holistic perspectives in affecting improvements in vocal functioning and intonation (Armstrong, 1996; Magee, 1999a; and Newham, 1999). Research has not focused on integrating these different concepts.

## **1.4 The research focus**

One part of this project aimed to identify and explore whether changes in emotion correlated with improvements in the expressive speaking potential of people with traumatic brain injury following participation in music therapy. It was envisaged that these research findings might stimulate further inquiries concerning music therapy's role in the interaction of various factors effecting the recovery of intonation function - namely musical, neurological, physiological and psychological processes.

While I think it is important for the music therapy profession to identify new applications for music therapy programs and substantiate these with outcome-based research, I also consider it important to identify and understand the factors influencing these outcomes. Such understandings may lead to modifications in clinical approaches, thereby increasing therapy effectiveness.

It was also anticipated that the findings of this project would provide valuable insights into client processes, which may be useful and relevant for the speech pathology discipline. In addition, this study may stimulate further interdisciplinary treatment and interdisciplinary research – i.e. between the music therapist and speech pathologist (Baker, 2000; 2003; Lee & Baker, 1997).

For the music therapy clinician, facilitating the instigation and development of processes is the very “essence” of music therapy. A greater understanding and recognition of the processes that occur during this area of communication rehabilitation may influence the way a music therapist works with a client and how the music therapy program is designed. For example, an enhanced understanding may influence the choice of music

material included, the choice of interventions, the method of program evaluation, the length of the program, etc. This study aimed to contribute to knowledge regarding these issues.

Despite the aforementioned reasons as to why this research was important, it is the future brain-injured clients that stand to benefit the most from these findings. Enhanced knowledge will help to refine current music therapy practices, thereby improving the effectiveness and quality of the future programs. In addition, by enhancing other health professionals' awareness of music therapy's application in this area of communication rehabilitation, an increase in client referrals for music therapy services may occur. Consequently, a greater number of clients may have the opportunity to improve their vocal expression, ultimately leading to enhanced life experiences.

## **1.5 Overview of thesis**

To establish if, how and to what degree singing songs can assist people with traumatic brain injury to improve their ability to use appropriate intonation, the thesis begins with an overview of the relevant literature. The literature review has been structured in such a way as to begin from a needs focus (a need to improve production of intonation) rather than a diagnostic focus (brain injury) and so for this reason, the review has not begun with an extensive review of the brain-injured client population.

The review contained in chapter 2 includes a description of the phenomenon of intonation in the non-clinical population to provide a frame for comparison with those who exhibit impairment in intonation. The importance of intonation in communicating both linguistic and affective functions has been described, with a more detailed reference to affective functions, as these is the major focus of this study. Also included in this section is the role intonation plays in creating personal identity.

The second part of chapter 2 delves into issues of the physiology and neurophysiology of the voice to describe how vocal control during intonation is formed. Neurological underpinnings of vocal fold control and intonation highlight the hemispheric specialization of both linguistic and affective production of intonation, which served to inform the design of the study. It provides a base from where intonation processing and music processing can be compared, and provides a rationale for why music may facilitate recovery of intonation from the neurological perspective.

Later in chapter 2, a brief section on brain injury functions as a prelude to a discussion on voice disorders. The reader is then introduced to various types of voice disorders which affect vocal fold flexibility, in particular those disorders resulting from neurological trauma. What follows is a description of the quality of life issues associated with voice disorders, to illustrate the need for developing treatment methods. To demonstrate the link between how music therapy programs might affect intonation secondary to its affect on physiological and psychological functioning, a presentation on how physiological tension and psychological functioning exacerbate the vocal flexibility of people who already have voice disorders has been included. Following on from this is a description of the speech pathology approaches reported in the literature, highlighting the limited range of existing treatment approaches.

The role of music therapy in treating intonation disorders is the focus of chapter 3. Clinical populations reported to have been treated for this impairment have been described with outcomes illustrating that music therapy researchers have already covered some ground in this area. A description of music therapy techniques adopted to treat people with impairments in intonation, combined with brief descriptions of other music therapy work with people who have neurological impairment, serve to illustrate how song singing may be useful to address intonation disorders in the brain-injured population. Finally, issues such as the frequency of sessions, length of the program, and the concept of group or individual sessions, have been discussed which inform the research design of this study.

The final part of chapter 3 discusses the rationale for adopting music therapy for treating this disorder. First, a comparison of song melody and intonation has been provided to illustrate the strong similarities between the two. Next follows a report on neuromusicological findings and their relationship to the neurology of intonation functioning. In addition, a discussion on the relationship between music and mood has been included to suggest that participation in music therapy may elevate clients' moods and/or initiate a relaxation response from them. The final part of this chapter summarises the main findings and presents the questions that form the basis of the investigation.

In chapter 4, the method design, intervention and procedures of data collection are described, with details of the assessment tools constructed specifically for this study. A description of the recruitment procedures and a summary of subject characteristics are included here. Following this is an outline of the procedures for selecting, isolating, cleaning audio signals and analysing the data within the software program. The final part

of this chapter presents the procedure for analysis of data and statistical tools adopted for the pooled subject results.

The results section of this thesis has been divided into two chapters. The first, chapter 5 presents the material for the four case studies and includes discussions on each case. In chapter 6, the results for the subjects' pooled data are presented in the same format as for each of the case studies and includes a cross-case comparison for each of the variables reported. The results are discussed briefly at the end of each sub-section of chapter 6.

The final chapter of the thesis, chapter 7, discusses the findings of these results in relation to previous findings and constructs and builds an argument for further research recommendations in this area. The limitations of the research are then discussed. The chapter concludes with an outline of the implications of these findings for clinical practice and a consideration of future directions for research in this area.



## **CHAPTER 2**

### **INTONATION IN COMMUNICATION**

The aim of this research was to establish whether singing songs improves the speaking intonation of people with brain injury. The following section outlines several areas pertinent to normal intonation as a point of departure. First, definitions of intonation and the terms and constructs related to it are provided. This is necessary as these constructs are referred to in the literature pertaining to disorders of intonation and its subsequent recovery. Following this, both linguistic and affective functions of intonation are introduced to illustrate the impact of disruptions to this function. Characteristics of normal intonation patterns for expressing differing moods are described so that it was possible to identify abnormalities in intonation functioning. Within this section, normative data on the vocal pitch for male and female speakers of varying age levels are detailed. A discussion focusing on personal, social and physical functions of intonation is also included to demonstrate a broader view of intonation's importance in people's lives. Following this, there is a brief description of the physiology of vocal sound production and sound frequency modification and the regions of the brain involved in activating these events.

The latter part of this chapter presents material concerning the population under investigation in this study, namely people with traumatic brain injury, and the intonation impairments they sustain. An overview of these disorders is included with discussion on the associated implications of such problems. Finally, a presentation of the treatment techniques and their effectiveness established by the speech pathology discipline is given to frame the introduction of music therapy concepts introduced in Chapter 3.

#### **2.1 Intonation and its linguistic functions**

Intonation, one feature of prosody, greatly contributes to the linguistic and paralinguistic communication of people. Bolinger (1986), a pioneer in exploring the complexities, functions and structures of intonation, defines intonation as the rise and fall of pitch as it occurs along the speech chain. He describes it as a sound-symbolic system, which conveys the emotions and attitudes of the speaker (Bolinger, 1989).

Intonation can be conceptualised from perceptual, acoustical and physiological perspectives. Perceptually, intonation is an indicator of changes in vocal pitch, the production of differing pitches combined in a pattern of intervals and set to a rhythm. The listener perceives it as a continuous modulation of rises and falls in pitch. Acoustically, intonation represents a series of changes in sound frequency, namely the fundamental frequency of the voice, and so can be measured and studied from a numerical perspective. Intonation can also be understood as the output from a series of physiological events, these comprising respiration and vocal fold action (Yorkston et al., 1987).

Intonation contour is the term used to describe the overall shape of the rises and falls in pitch over time in a spoken phrase, without regard for the exact pitch intervals (Hargrove & McGarr, 1994; Patel, Peretz, Tramo, & Labreque, 1998). These contours comprise of several components: pitch height, pitch range, pitch variation and pitch slope. Pitch *height* describes the overall pitch of the voice used in speech and can be described subjectively as low, middle or high. Pitch *height* is most frequently described in terms of frequency, herein referred to as the *fundamental frequency* ( $F_0$ ). The  $F_0$  refers to the characteristic frequency vibration (expressed in Hertz) of the vocal folds that individual speakers adopt, excluding all harmonics or overtones (Hargrove & McGarr, 1994; Joannette, Goulet, & Hannequin, 1990; Pittman, 1994). Pitch *slope* describes the rate of change in the  $F_0$  at the syllable, word, phrase or sentence level. Pitch changes that occur rapidly are described as having steep slopes, whereas those that occur slowly have gradual or flat slopes. Pitch *range* (acoustically referred to as frequency range) refers to the entire range of frequencies used over a given intonation contour. They can be described as small, medium or large. Finally, pitch *variation* is the term ascribed to communicate the variability of the intonation contour (known as fundamental frequency variability). A low level of pitch variation is indicative of a monotonal speaking style (Wymer, Lindman, & Booksh, 2002).

The intonation of spoken phrases performs linguistic functions in helping the listener make sense of a series of sounds (Perkins, Baran, & Gandour, 1996). In this way, intonation contours contribute to lexical and syntactical understanding. A thorough description of such functions is beyond the scope of this text and is not regarded as necessary to explain the outcomes of the research project. A description of these functions is set out in Appendix 10.1 for the reader's reference.

## 2.2 Affective and identity functions of intonation

*Extreme emotional responses can cause vocal pitch in intonation to go more or less out of control.... the sweep of the melody as a whole and the size of the jumps that mark the accents exceed what one would expect in ordinary discourse* (Bolinger, 1986, p.12).

It is well established that intonation contours serve as mirrors for emotional states (Bolinger, 1986; 1989). Bolinger (1989) emphasises that emotion is so entwined in intonation contours that a speaker's mood can be perceived even in sentences containing no emotional content. Newham (1998) considers that the voice is the major bridge between people's inner and outer worlds where mood, emotion, thought and experience is reflected in the intonation pattern.

It is also recognised that affective intonation patterns for the four established basic or psychologically primitive emotions - happiness, sadness, anger and fear – are to a certain extent stereotyped according to pitch height, pitch variation, pitch contour, slope and pitch range (Apple, Streeter, & Krauss, 1979; Bachorowski, 1999; Davitz & Davitz, 1959; Fairbanks & Provonost, 1939; Mozziconacci & Hermes, 1997; Murray & Arnott, 1993; Pittman, 1994; Scherer, 1991). However, discrepancies exist in what constitutes such stereotyped patterns. A full review of this literature is beyond the scope of this thesis, but a summary of the main findings is outlined in Table 1 below so that future comparison between the norm and the clinical population can be established.<sup>2</sup>

**Table 1. Intonation characteristics for basic emotions**

| <i>Emotion</i>   | <i>Pitch variation</i> | <i>Pitch height</i> | <i>Slope</i>   | <i>Pitch range</i> |
|------------------|------------------------|---------------------|----------------|--------------------|
| <i>Anger</i>     | Large                  | High                | Steep          | Wide               |
| <i>Sadness</i>   | Small                  | Low                 | Gradual        | Narrow             |
| <i>Happiness</i> | Large                  | High                | Steep          | Wide               |
| <i>Fear</i>      | Small/Large*           | High                | Steep/Gradual* | Wide               |

\* Denotes inconsistencies in the research findings.

<sup>2</sup> Only studies with English speaking subjects have been included as language can play a role in the contour produced. Several research design differences have been identified and are described in Appendix 10.2.

All people are different in gender, age, nationality, socio-economic class, personality and physiological build. Such differences are reflected in the highly individualised and distinctive timbre and patterns of intonation created by each individual and contribute to the formation of a person's identity. However, several common vocal characteristics exist for certain populations. The following section briefly outlines these.

A person's pitch height (herein  $F_0$ ) is partially determined by age, gender, nationality and social class. Most females have a mean  $F_0$  of approximately an octave higher than that of males, however, this depends directly on age (Colton & Casper, 1996; Decoster & Debruyne, 2000). Table 2 details the different  $F_0$  estimates for females and males according to age as stipulated in the literature review by Colton & Casper (1996). It must be mentioned however, that many of these studies did not define the proportion of subjects from different ethnic backgrounds, this perhaps influencing the mean values calculated. For example, some ethnic groups may typically have higher or lower voices based on the physical structure of their vocal mechanisms (Colton & Casper, 1996).

**Table 2. Mean fundamental frequency of male and female subjects**

| <b>Male</b> |                                       |                       | <b>Female</b> |                                       |                       |
|-------------|---------------------------------------|-----------------------|---------------|---------------------------------------|-----------------------|
| <i>Age</i>  | <i>Mean <math>F_0</math><br/>(Hz)</i> | <i>SD (semitones)</i> | <i>Age</i>    | <i>Mean <math>F_0</math><br/>(Hz)</i> | <i>SD (semitones)</i> |
| 14          | 242                                   | 3.4                   | 11            | 238                                   | 1.5                   |
| 19          | 117                                   | 2.1                   | 19            | 217                                   | 1.7                   |
| 20-29       | 120                                   |                       | 20-29         | 224                                   | 3.8                   |
| 30-39       | 112                                   |                       | 30-39         | 196                                   | 2.5                   |
| 40-49       | 107                                   |                       | 40-49         | 189                                   | 2.8                   |
| 50-59       | 118                                   |                       | 50-59         | 200                                   | 4.3                   |

Pertinent to the present study is the finding that the  $F_0$  for adolescent males and females change over a three to six month period (Aronson, 1990). This period of change resolves by age 15 for females and 14-16 for males. Subsequently, testing treatment effectiveness should exclude subjects younger than 16 years of age because the reliability of the findings would be questionable. Other gender differences include the finding that women differ in the way they inflect their voice, utilising a larger pitch range than men (Abe, 1980).

Differences in social class, occupation and national or regional place of origin are also reflected in the subtle differences in intonation patterns (and speaking styles) (Abe, 1980; Hargrove & McGarr, 1994). Therefore in experimental studies, differences related to ethnic and socioeconomic background should be taken into account when forming matched experimental and control groups.

While intonation patterns typically match the age, gender, nationality and class of people, individual differences also exist. People typically present with their own intonation style,  $F_0$ , and speaking tempo. These components, combined with an individualised vocal timbre, form an individual voiceprint, an acoustic mirror (Abe, 1980; Newham, 1999; Pittman, 1994). Newham (1999) proposes that the sound of people's own voices influence the way they perceive themselves. It serves to remind them of who they are, affirming and reinforcing their self-image (Newham, 1993). Newham (1998) argues that positively modifying speaking styles can enhance people's self-perceptions and raise their self-esteem. This point is particularly important for the current study because self-perceived impairments in speaking styles may directly affect feelings of self-worth in people with traumatic brain injury.

## 2.3 Physiology and neurology of intonation

Vocalisation is a highly integrated motor pattern involving the respiration, laryngeal and oro-facial muscles. Phonation itself is generated through the rapid opening (abduction) and closing (adduction) of the vocal folds, which causes air from the lungs to be released through the glottis in a series of infinitesimal puffs, this creating a wave heard as the sound of the human voice (Newham, 1998).<sup>3</sup> To summarise simply, phonation is a result of the alpha-motor nerve fibres innervating the abductor and adductor muscles (Wallin, 1991). Altering the physical structure of the vocal folds - by altering their length, mass and tension - activates changes in frequency. Vocal range is directly linked to the degree by which these vocal folds can be altered (Colton & Casper, 1996; Sonninen & Hurme, 1998). The greater the potential to adjust vocal fold length, mass and tension, the greater the potential for creating a wide vocal range.

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<sup>3</sup> For the purposes of this study, a detailed description of the phonatory structure was not considered necessary and has consequently been omitted. Please refer to Newham (1998) for more detailed descriptions of the mechanism.

Leonard, Ringel, Horii, & Daniloﬀ (1988) examined the ease with which people can raise or lower vocal pitch. They found that because the pitch lowering mechanism is also involved in the constriction and protection of the airway, pitch lowering is achieved more quickly but with less precision when compared with the pitch raising mechanism. They also proposed that pitch lowering is achieved more quickly and easily because it involves movement from a point of greater tension to a point of less tension. In contrast, rises in pitch involves movement to a point of greater tension, this requiring more control.

Intonation is activated through a series of phonatory events derived from neurological processes. Research evaluating specific regions of the brain responsible for the control of intonation has led to conflicting findings particularly related to the hemispheric specialisation of intonation. Two predominating concepts – the *functionalist hypothesis* and the *parallel processing model* – have attempted to explain the neurological control of intonation. Both of these models have received support from several studies.

The *functionalist hypothesis* model (Shipley-Brown, Dingwall, Berlin, Yeni-Komshian, & Gordon-Slant, 1988; Walker, Daigle, & Buzzard, 2000) claims that hemispheric specialisation is not determined by the acoustic properties of intonation (contour, vocal range etc) but rather by the function of those properties within the sentence. According to those who support this position, the left hemisphere (LH) (dominant for language) processes intonation contours that perform linguistic functions, whereas the right hemisphere (RH) (dominant for processing of non-linguistic information) processes intonation contours that perform non-linguistic functions such as the expression of mood (Perkins et al., 1996). This model therefore assumes that both the LH and RH are capable of processing and controlling the frequency of the voice and that there is a bilateral representation of the intonation structure with each intoned phrase spoken. Each hemisphere abstracts those properties essential to the type of analysis that is performed in that hemisphere. Studies by Emmorey (1987), Cancilliere & Kertesz (1990) and Walker et al. (2000) support the functionalist hypothesis model.

The *parallel processing model* (Shipley-Brown et al., 1988) assumes the RH is dominant for processing the acoustic correlates related to intonation (such as pitch), while the LH simultaneously processes the segmental information contained within a sentence (rhythm and pause). Those supporting this position regard the differences between the linguistic and non-linguistic functions as irrelevant and consider that there are specialised areas within the brain which have been assigned to perform the differing functions of

duration, intonation, tempo, intensity etc (Perkins et al., 1996). Studies by Van Lancker & Sidtis (1992) and Patel et al. (1998) support this model.

Firm conclusions concerning hemispheric specialisation for the expression and perception of intonation are difficult to draw. Some studies have established that during the perception of affective prosody, the RH, and a combination of the RH and LH were important in discriminating the mood of the speaker.<sup>4</sup> However, the basal ganglia, either by itself or in combination with the RH, has also been implicated in processing affective intonation (Table 3). In addition, the prefrontal cortex has been suggested as having some involvement in the process.

**Table 3. Regions of the brain involved in affective intonation perception**

| <i>Lesion location</i>                      | <i>Studies</i>   |
|---|--|
| <i>Right Hemisphere</i>                     | Blonder, Bowers, & Heilman (1991)<br>Bowers, Coslett, Bauer, Speedie, & Heilman (1987)<br>Emmorey (1987)<br>Joanette et al. (1990)<br>Tucker, Watson, & Heilman (1977) |
| <i>Right Hemisphere and Left Hemisphere</i> | Pell (1998)<br>Pell & Baum (1997)<br>Perkins et al. (1996)<br>Tompkins (1991)<br>Tompkins & Flowers (1987)<br>Van Lancker & Sidtis (1992)                              |
| <i>Right Hemisphere and Basal Ganglia</i>   | Gandour et al. (1997)<br>Cancilliere & Kertsz (1990)<br>Karow (1998)   |
| <i>Prefrontal</i>                           | Cancilliere & Kertsz (1990)<br>Ross (1993)   |

<sup>4</sup> Note that the studies do not specifically assess intonation but prosody (which includes intonation). Therefore, it is possible that the bilateral activation of the hemispheres may be a consequence of the additional rhythmic involvement. This finding was noted by Van Lancker & Sidtis (1992) whereby people with RH damage relied more on durational cues to perceive meaning whereas people with LH damage relied more on melodic cues.

Only a few studies have assessed the expression of affective intonation. Despite the paucity of research in this area, lesion locations associated with impairment in affective intonation expression are similar to those for affective intonation perception. Involvement of the LH and RH, the combination of RH and basal ganglia, the basal ganglia without LH or RH involvement, and the prefrontal areas have been found. These findings are listed in Table 4.

**Table 4. Regions of the brain involved in affective intonation expression**

| <i><b>Lesion Location</b></i>               | <i><b>Studies</b></i>                                       |
|---|---|
| <i>Left hemisphere and right hemisphere</i> | Joanette et al. (1990)                                      |
| <i>Right hemisphere and basal ganglia</i>   | Cohen, Riccio, & Flannery (1994)<br>Gandour et al. (1997)   |
| <i>Right hemisphere</i>                     | Ross, Edmondson, & Seibert (1988)<br>Tucker et al. (1977)   |
| <i>Basal ganglia</i>                        | Cancilliere & Kertsz (1990)                                 |
| <i>Prefrontal</i>                           | Cancilliere & Kertsz (1990)                                 |
| <i>Subcortical</i>                          | Brådvik, Dravins, Holtås, Rosén,<br>Ryding, & Ingvar (1991) |

The complexity and discrepancies in these research findings suggest that intonation control originates in several regions of the brain and that it does not follow the reliable pattern of brain organization seen for speech and language. It also suggests that the neural basis of intonation is not simple or straightforward (Baum & Pell, 1999).

Many of the inconsistencies in the findings regarding hemispheric specialisation for intonation may be due to the methodological differences across studies. For example, stimuli used to examine responses of people with left hemisphere damage, right hemisphere damage or no hemispheric damage (normal controls) have differed between studies. Some research studies presented subjects with natural, well formed utterances which were semantically and emotionally congruent with the intonation target (Blonder et al., 1991; Cancilliere & Kertesz, 1990; Grandour et al., 1997; Patel et al., 1998; Pell & Baum, 1997; Perkins et al., 1996; Tompkins, 1991; Tomkins & Flowers, 1987; Van Lancker & Sidtis, 1992). Others isolated the intonation contour by means of low-pass filtering of the linguistic content (Pell & Baum, 1997; Perkins et al., 1996) or by intoning



nonsense sentences (Pell & Baum, 1997). It is not clear from these studies how such methodological differences affected the results.

One point not discussed in the literature concerns possible differences in the area of neurological activation when intonation patterns are consciously generated or spontaneously generated. For example, differing regions of the brain may be activated when people give an intoned sentence in response to a stimulus that evoked an emotional response, when compared with people consciously inserting melody in their sentences. These differences may be evident when comparing people experiencing genuine emotional responses and those who may be *acting*.

## 2.4 Traumatic Brain Injury

Acquired brain injury refers to injury to the brain resulting in the deterioration of cognitive, physical, emotional or independent functioning (Department of Human Services and Health, 1994). It can be an outcome of trauma, hypoxia, infection, tumour, substance abuse, degenerative neurological disease or stroke. Subsequent impairments may be either temporary or permanent, partial or total, or result in psychosocial maladjustment. People who have received traumatic brain injury (TBI) are the population under investigation in the current study. TBI refers more specifically to acquired brain injury caused by a trauma – for example, a blow to the head. TBI is the most prominent subgroup of the acquired brain injury population, however many studies use the term ABI even though all the subjects in the study were specifically people with TBI (Fortune & Wen, 1999).

During the year 1996-1997<sup>5</sup>, Australia reported 27,437 hospitalisations with a TBI diagnosis, a rate of 149 per 100,000. The highest proportion of TBIs was found among young people aged between 15 and 19 years (284 per 100,000). The next highest incidence reported were children aged between zero to four years (244 per 100,000). Incidence of males (70%) was substantially higher than females (30%) (Fortune & Wen, 1999) and the majority of TBIs were caused by road trauma (Heath Department, Victoria, 1991).

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<sup>5</sup> At the time of the research project, there were no other published studies reporting more recent statistics.

The two types of primary head injury caused by motor vehicle accidents are lesions and diffuse axonal injury. *Lesions* are “zones of tissue with impaired function resulting from damage by disease or wounding” (Oxford Medical Dictionary, 1996). They are caused by structural stresses and dislocation of brain structures originating from the sudden acceleration or deceleration of the head during road traffic accidents (Alexander, 1989; Cohen, 1993; Sholberg & Mateer, 1989). Lesions are easy to identify as sites of damage are highlighted clearly in computerized axial tomography and magnetic resonance imaging scans.

*Diffuse axonal injury* is caused when the head is subjected to twisting movements associated with road traffic accidents. These movements generate high velocity rotation of the brain within the skull, which strain, stretch, tear and shear delicate nerve fibres and blood vessels (Alexander, 1989; Cohen, 1993; Sholberg & Mateer, 1989). Diffuse axonal injury usually results in widespread diffuse brain dysfunction and can cause death (Ponsford, Sloan, & Snow, 1995; Sholberg & Mateer, 1989). It is difficult to identify diffuse axonal injuries in scans because the injuries are not localized, but are, as the name suggests, diffused throughout the brain.

After a period of coma and posttraumatic amnesia, recovering patients begin to present with a range of different problems. Such problems can include voice disorders, which result in impairment in intonation.

## 2.5 Intonation impairments

At present, specific labels for the varying symptoms of intonation do not exist, and they are simply categorised under the umbrella of impairments in prosody (aprosodia). Further, the subtle differences in types of prosody are not well described in the literature. Typically, impairments in intonation are listed under the broader categories of voice disorders. The following description summarises the major voice disorders caused by neurological damage which involve impairments in intonation.<sup>6</sup> They indicate disruption in the use of pitch, namely monopitch, abnormally high or low pitch, or poor pitch control. The main difference between these voice disorders is the manifestation of the symptoms and the way the vocal mechanism functions in response to the associated neurological injuries.

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<sup>6</sup> These summaries are based on the descriptions given by Aronson (1990).

*Flaccid Dysphonia* occurs from damage to the motor units of the cranial or spinal nerves causing paresis (weakness) or paralysis (immobility) of the laryngeal muscles. There is a loss of or decrease in muscle tone with the vocal folds being fixed in the abducted position. Unilateral lesions cause unilateral vocal fold paralysis which in turn causes severe breathiness or a whispered voice, reduced loudness and reduced pitch range. Bilateral lesions cause bilateral paralysis and typically result in moderate to severe impairment in altering pitch.

*Spastic Dysphonia* is associated with lesions to the upper motor neuron where the vocal folds are in a hyper-adducted position. The voice presents typically as harsh, strained and/or strangled quality, abnormally low pitch, monopitch, monoloudness, and reduced loudness.

*Mixed Flaccid-Spastic Dysphonia* is characterised by a mix of flaccid and spastic musculature behaviour. It may be characterised by either harsh strained voices, breathiness of varying degrees, reduced loudness, audible inhalation and wet hoarseness, and a high pitch or low pitched voice.

*Ataxic Dysphonia* is associated with lesions to the cerebellum, which is responsible for coordinating muscles and regulating skilled movements. These lesions result in loss of muscle coordination, the ability to measure the required range of motion, and intention tremor, and are characterised by clumsy or uncoordinated movements. The characteristics of vocal presentation include sudden bursts of loudness, irregular increases in pitch and loudness, monopitch, harsh voice quality, and monoloudness.

*Hyperkinetic Dysphonia* is usually associated with basal ganglia lesions or may be associated with lesions of the basal ganglia and subthalamic nucleus. Difficulties arise by the over-contraction of laryngeal and respiratory muscles resulting in intermittent hyperadduction as well as quick, jerky, irregular and unpredictable movements. Corresponding symptoms manifest in irregular pitch fluctuations, monopitch, excess loudness variation, strained-strangled voice quality, and sudden forced inspiration or expiration.

*Hypokinetic Dysphonia* is associated with lesions to the basal ganglia. It is characterised by monotone speech with reduced vocal range and breathy voice quality. Monotone speech arises from the rigidity and reduced range of the intrinsic and extrinsic laryngeal muscles. The adductor and abductor movements are bilaterally symmetric however there is an incomplete closure of vocal folds, which accounts for the breathy voice quality.

Although there have been no studies that have specifically assessed the incidence of voice disorders in people who have received TBI, one study assessed the incidence of dysarthria in the TBI population. People diagnosed with dysarthria frequently present with voice disorders. A study by Sarno, Buonaguro, & Levita (1986) found that 33% of people with TBI displayed symptoms of dysarthria. Such a high incidence suggests that a substantial proportion of people with TBI may have resulting impairments in intonation.

Some voice disorders cause severe disability with regard to producing intelligible speech requiring an excessive use of energy just to convey a simple, short sentence. When this occurs, assisting people to become more intelligible in their communication is of utmost importance. However, in situations where the primary deficit is intonation production, the voice disorder becomes an issue of quality of life and the intonation disorder in its own right threatens the psychological equilibrium of the person effected. Aronson (1990) reports that self consciousness, feelings of inadequacy, paranoid ideation, diminished interpersonal communication, social withdrawal, alcoholism, depression and suicidal tendencies are found in a majority of such patients to some degree.

A perceived sense of altered self may arise when a person realises that their vocal communication is impaired. For example, feelings of inadequacy or frustration may arise when the emotional intent of communication has been misunderstood. Prolonged feelings of poor self-perception, inadequacy, and frustration may lead to the withdrawal from interpersonal communication which may in turn lead to more serious problems such as depression. Aronson (1979, cited Aronson, 1990, p.168) reported that for one type of dysphonia (spastic type), 64% of people became socially withdrawn and later depressed. Similarly, Benninger et al. (1998) found that patients with dysphonia had lower levels of social functioning, lower scores of mental health, role functioning and emotional functioning than the other clinical groups.

## **2.6 A holistic perspective of intonation**

The focus of this chapter, so far, has been on the neurological factors involved in intonation and how the disruption of neurological pathways can cause intonation impairment. However, some researchers have viewed vocal performance (and therefore intonation) from a more holistic perspective. Such philosophical approaches understand both the emotional state and physical state as key factors in intonation functioning.

### 2.6.1 Physiological influences on intonation

Phonation and speech depends on the effective activation and modification of the vocal fold mechanisms. Accordingly, disruption to the body's balance can affect vocal fold activity and therefore affect the expressive potential of the voice. Such disruptions to body balance may include physical illness, debilitation, negative postural habits or movement patterns, or muscular tension. These disruptions predispose the highly sensitive laryngeal muscles to tension, fatigue, rigidity and constriction (Aronson, 1990; Bunch, 1997; Newham, 1999; Wilson, 1987) which can negatively affect vocal freedom, reduce vocal range, and therefore optimal vocal performance (Pittman, 1994; Stengel & Strauch, 2000).

Fatigue particularly affects vocal performance. Abe (1980), Kitch & Oates (1994), and Welham & MacLagan (2003) noted that the elasticity in the laryngeal muscles was lost when people became tired, thereby lowering  $F_0$  and narrowing the  $F_0$  range. Conversely,  $F_0$  rises when people experience elation and great energy (Abe, 1980). This point is relevant to the present study as high levels of fatigue are common in people with TBI. Tremendous energy is involved in performing even the simplest of tasks and fatigue often results (Prigatano, 1999b). Further, damage to almost any area of the brain seems to predispose people with TBI to fatigue (Prigatano, 1999b). Oddy, Coughlan, Tyerman & Jenkins (1985) noted that even seven years post-injury, 43% of patients fatigue easily.

Another physiological consideration for intonation production is the overall posture of the speaker. It is well accepted that posture influences the efficiency and effectiveness of respiration during speaking and singing (Bunch, 1997). Not so well known is that posture can also influence the vocal fold behaviour and therefore can affect intonation. When the body is out of alignment, the larynx is not properly positioned and the full functions of the vocal folds cannot be used to their full potential. Consequently, this affects the control of pitch (Bunch, 1997). Among many recommendations for standing posture, Bunch (1997) states the importance of good postural alignment, which includes holding the head and chest in a relaxed but also vertical position.<sup>7</sup> In a study with a non-clinical population, Lin, Jiang, Noon, & Hanson (2000) found that head extension was associated with increased  $F_0$ . Unfortunately, no such studies of the effect of posture on intonation were found with people who have TBI so it is unclear as to the degree of impact this factor has on reducing intonation impairment.

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<sup>7</sup> The reader can refer to Appendix 10.3 for further recommendations in correct speaking and singing posture.

### 2.6.2 Emotional influences on intonation

*“Vocalisation is not just the larynx making sound; it has to be activated by the brain; connected to emotional expression and to the will” (Davis, 1998, p.15).*

The departure point of this study is that people’s emotional state affects their potential for full vocal expression. There is substantial evidence to support this notion. First, intonation contours have been shown to form stereotyped patterns for the expression of different emotions (Table 1), suggesting a direct link between emotion and intonation.

Second, research shows that the regions of the brain controlling emotional responses are also responsible for the motor control of the voice during speech and singing (Davis, 1998; Zhang, Davis, Bandler, & Carrive, 1994). Here, emotionally induced stimulation of the midbrain periaqueductal gray (PAG) produces complex and integrated patterns of involuntary muscle changes affecting breathing, laryngeal, facial, and oral muscle movement. Here, emotion and the act of speaking/singing are closely linked (Davis, 1998).

Third, Benninger (1994) and Newham (1998) propose that hormonal releases associated with emotional responses directly affect the voice, and therefore intonation. Their premise is based on the physical connection between the larynx and the thyroid cartilage, which is a dominant station on the endocrine circuit. The voice is highly susceptible to the mood state of the individual because hormonal release is such an integral component to emotional experience (Taylor, 1997). The existence of the relationship between emotionally stimulated hormonal releases and intonation is yet to be scientifically tested.

The use of the voice as a diagnostic tool presents a further argument supporting the relationship between emotional state and intonation contour. Vocal characteristics including the variability and range of  $F_0$  are part of the assessment in diagnosing affect disorders (Alpert et al., 2001; Frolov et al., 1999; Garcia-Toro et al., 2000; Kuny & Stassen, 1995; Naarding, van den Broek, Wielaert, & van Harskamp, 2003), schizophrenia (Fricchione, Sedler, & Shukla, 1986) and depression in Parkinson’s Disease patients (Benke, Bosch, & Andree, 1998). Given this, there is a general acceptance in the field of psychiatry that mood states and vocal characteristics are acutely linked.

Stress has been identified as contributing to vocal change and therefore intonation contour (Aronson, 1990). Aronson (1990) notes that during periods of stress, subcortical

emotional release occurs, this resulting in the disintegration of phonatory and respiratory control. Here, the body attempts to cope with the stress by increasing its volume and flow of oxygen, to meet the body's increased metabolic demands. To achieve this, firm adduction of vocal folds and wide abduction occurs to facilitate the increase in volume and flow of oxygen (Aronson, 1990, p.119). This changed physiologic state affects the fine control of vocal pitch and explains why the voice is sensitive to periods of stress.

No such study has examined how stress or emotional response affects an already present impairment of intonation in people with TBI. However, Aronson (1990) notes that stress, which causes tension, can exacerbate an already present voice disorder through further constriction of vocal fold function. He states that specific voice changes affected by stress in people with voice disorders include voice quality, pitch, and loudness.

### **2.6.3 Emotional and cognitive disturbances in people with traumatic brain injury**

People with TBI experience a range of disturbances to mood and affect. It is estimated that the proportion of people with TBI who suffer mood disturbances range from 26% to 77% of the total TBI population (Bowen, Neumann, Conner, Tennant, & Chamberlain, 1998; Prigatano, 1999a; Schramke, Stowe, Rateliff, Goldstein, & Condray, 1998). Such disturbances may be neuroanatomical, neurochemical or psychosocial in origin (Prigatano, 1999b). Common disturbances that may be present in people with TBI include anger, restlessness, frustration, irritability, agitation, anxiety, sadness or loss of motivation.

With specific reference to anxiety, Castillo, Starkstein, Fedoroff, Price, & Robinson (1993) found nearly 40% of people who received an acquired brain injury reported anxiety symptoms, with 27% meeting the criteria for generalised anxiety disorder. In a study of people with TBI, 25% presented with major depression (Fedoroff, Starkstein, Forrester, Geisler, Jorge, Arndt, & Robinson, 1992).

Depression has been found to be directly linked with the left hemisphere damage, particularly left frontal regions (Prigatano, 1999b). A lack of insight is also a common outcome of TBI (Prigatano, 1999b; Prigatano, & Schacter, 1991). Oddy et al. (1985) reported that 40% of people with TBI display poor insight into their impairments. These studies highlight that mood disturbance are likely to be present in a significant proportion of people with TBI who participate in research studies.

## 2.7 Speech therapy approaches to treating intonation impairments

Treating impairments in intonation has largely been the domain of speech pathologists. However, brief reviews of their approaches, particularly the ones involving singing, are included to provide a platform for comparison between findings in their research and that of the present study.

Speech pathology literature describing interventions for treating impairments in intonation are scarce. Pannbacker (1998) reviewed over 100 studies on voice treatment techniques and found that only ten of these focused specifically on people with neurological impairments. Of these ten, only one study focused specifically on people with TBI and it was not an experimental study, but a report on two cases. Consequently, the techniques described have not yet been evaluated through research.

The term *feedback* describes a set of techniques whereby the therapist provides information to clients on the acceptability of their performance. Extensive feedback is initially given to enable clients to correctly perform the target response. With time, the speech pathologist withdraws the degree and frequency of feedback to encourage independence (Hargrove & McGarr, 1994). Feedback may be auditory, visual or verbal, or a combination of these. Auditory feedback provides non-verbal acoustic information on performance and normally consists of audio-recordings of client performance that are replayed as a feedback tool (Colton & Casper, 1996). Verbal feedback involves the therapist providing clients with positive and negative verbal descriptions of their vocal performance (Hargrove & McGarr, 1994). Visual feedback techniques involve the use of gesture, instrumental printouts and the use of computerised visual feedback tools such as Visi-Pitch (3.2.3) to provide feedback to clients. Although not discussed in the literature, feedback techniques seem appropriate for people with TBI as the techniques are concrete, requiring less cognitive skill to understand. The question of independence may be problematic if clients become dependent on feedback in their natural speaking.

The concept of *self-monitoring* involves the clients evaluating and critiquing their own performance according to some predetermined criteria set between the client and therapist (Hargrove & McGarr, 1994). This technique is an extension of feedback techniques, whereby clients are encouraged to provide their own feedback and then in turn monitor their performance when out-of-therapy and in real life situations.



*Imitation* involves clients copying and repeating verbal material presented to them by the speech pathologist (Hargrove & McGarr, 1994). While this would appear to be a very concrete method of developing skill, it is unclear whether this facilitates transference to clients' normal conversations. This is because in imitation, intonation patterns are consciously inserted into speech, which is different to unconscious and spontaneous intonation that characterises typical conversations.

*Modelling*, a less structured technique than imitation, involves the therapist presenting information and/or examples of ideal intonation patterns. This technique promotes greater independence than imitation and is better suited to the transference of skills out-of-therapy.

*Relaxation techniques* have been advocated particularly when laryngeal tension contributes to the limited range of vocal pitch (Aronson, 1990; Colton & Casper, 1996; Elias, Raven, Butcher, & Littlejohns, 1989; Murray & Rosen, 2000; Prater, 1991; Stengel & Strauch, 2000). Relaxation techniques would be appropriate for people with TBI given that tension contributes to restricted vocal range. However, people with TBI may have poor awareness of tension levels in their bodies and may not be able to identify tension while out-of-therapy. Therefore, relaxation exercises might only be useful within therapy sessions.

*Singing and vocal warm-ups* have been documented in the speech pathology literature, although there are few details or guidelines provided (Carroll, 2000; Hargrove & McGarr, 1994; Murray & Rosen, 2000).

Carroll (2000) described the *text-to-song, song-to-speech* exercise where clients sing an arbitrary melody for the text and then speak the same text. She argues that this increases vocal flexibility. This technique seems to encourage the transfer of vocal skills from the sung phrase to the spoken phrase, although Carroll does not discuss this. Further, Carroll has not described whether this arbitrary melody attempts in any way to mirror the intonation pattern of the text.

Carroll (2000) also describes a sliding 3<sup>rd</sup> exercise whereby clients should control minute vocal changes rising up and then down through a major 3<sup>rd</sup>. She asserts that this gradual slow change in pitch improves the control of the thyroarytenoid and cricothyroid muscles (although she provides no data to support this). Carroll (2000) states that this exercise should be repeated until the client is able to move slowly and smoothly through the rising and falling interval.

As well as using vocal exercises to develop vocal control, these exercises can serve as warm-ups which are important in optimising vocal output. As the vocal folds are muscles, Elliot, Sundberg, & Gramming, (1997) proposed that in the same way that warm-up of other muscles influence performance, the same should apply to the vocal muscle. Blaylock (1999) states that 15 minutes of vocal exercises could be considered a vocal warm-up.

## **2.8 Conclusion**

It is clear from the aforementioned discussion that intonation plays a variety of roles in conversation. Aside from its linguistic functions, it serves to indicate affective meaning and the inner emotions of the speaker. Further, intonation patterns signify the gender, age, and nationality of speakers and serve to reinforce a sense of self. The research has shown that certain culturally consistent stereotypical contours exist for the four basic emotions of happiness, sadness, anger and fear, pointing to the conclusion that intonation is a necessary innate communication tool for successful intra and interpersonal functioning.

For phonation, and therefore intonation to occur, there appears to be a dynamic interplay between different regions of the brain and the phonatory mechanism. However, firm conclusions as to the specific sites for controlling intonation production remain yet to be drawn. As technology advances, it is envisaged that these questions may be answered.

This review described several voice disorder diagnoses and compared their differences in lesion sites and corresponding intonation impairment characteristics. A detailed discussion on physiological and emotional factors influencing vocal functioning was included to illustrate that intonation impairments are not purely the result of neurological damage. Data on the high incidence of voice disorders among people with TBI and the corresponding social, emotional and psychological implications associated with the voice disorder, point to the need for treatment interventions to be documented and researched.

The incidence of mood disorders in the TBI population shows that a large proportion experience a range of clinically significant mood states, including fatigue, anxiety and depression. Such mood states are thought to affect intonation contours or exacerbate already present intonation impairments.

The literature reviewed indicates a gap in the development and testing of speech pathology techniques specifically for impairments in intonation production. However, several authors present possible approaches that are based on the common therapeutic principles of feedback, imitation and modelling, self-monitoring, relaxation and singing. The literature shows that some computer-based rehabilitation tools have been developed to treat intonation problems, although there have been no studies to test these claims. Instead, the research has been used to verify their reliability at a diagnostic level.

The next chapter introduces the reader to aspects of music therapy research and theory to provide a rationale for the employment of a song-singing program in early-to-recover patients with TBI.

## **CHAPTER 3**

# **MUSIC THERAPY INTERVENTIONS FOR TREATING IMPAIRMENTS IN INTONATION**

The focus of this chapter is to present music therapy research designed to treat intonation and to provide a theoretical frame for understanding the research focus and design. The first section surveys and critiques the literature about treating intonation impairments in different clinical populations. Music therapy studies concerning other prosodic impairments and general impairments resulting from TBI have been omitted to ensure that a detailed discussion of the material pertinent to this study was possible. Several areas are discussed including treatment focus areas, populations, research methods, outcomes, music therapy techniques, and the length and frequency of programs and sessions. These have informed the research design adopted in this study. Where documented, the music material cited in these studies and the studies' reliability and validity are also outlined.

Following this, the theoretical departure point to this study is built by presenting a broader perspective of music and music therapy and its relationship between speech and language. A presentation of neuromusical findings has also been included for comparison with the neurology of intonation. A discussion on singing as a training exercise is presented to argue the concept that singing trains the voice which can then be used in speaking. Finally, a discussion on music and mood has been included.

### **3.1 Clinical populations and treatment outcomes**

Research into the effects of music therapy on intonation is also somewhat limited, as expected given the paucity of research arising from the speech pathology discipline. Accordingly, the following review was extended to include all populations where music therapy treatment focused on enhancing pitch control,  $F_0$ ,  $F_0$  variability and  $F_0$  range. In fact, there were only two experimental studies that examined the effects of music therapy on intonation, neither of which focused specifically on the TBI population (Cohen & Masse, 1993; Darrow & Starmer, 1986). Most of the studies reported are case studies

(Cohen, 1992; 1995; Darrow & Cohen, 1991; Haneishi, 2001) or anecdotal reports (Kennelly, Hamilton, & Cross, 2001; Livingston, 1996; Zoller, 1991).

There are limited experimental studies in the TBI area for several reasons. First, there are only a small number of music therapy clinicians working in this area, these people being likely to write up case study designs in an attempt to at least provide some literature in this field, a trend also evident in the neurology, neuropsychology and speech pathology fields. Second, designing experimental studies requires the formation of homogenous groups. Finding subjects within a given time frame who have similarities in: site of lesion, level of injury severity, phase of recovery, age etc, may be unattainable. Third, as there are few citings of music therapy in the field of TBI, music therapists have tended to document the more disabling deficits such as aphasia (Albert, Sparks, & Helms, 1973; Baker, 2000; Cohen, 1992; Cohen & Ford, 1995; Krauss & Galloway, 1982; Lucia, 1987; Magee, 1999a; Rogers & Flemming, 1981; Sparks, Helms & Albert, 1974; Sparks & Holland, 1976; Taylor, 1989), physical functioning, (Lee & Baker, 1997; Livingston, 1996; Lucia, 1987) and cognition (Lee & Baker, 1997; Livingston, 1996), perhaps in order to establish a place on the treatment team.

### **3.1.1 Components of intonation treated**

The focus areas addressed in the literature concern the treatment of three main impairments –  $F_0$ ,  $F_0$  variability and range, and pitch control. There were no studies that studied the characteristic intonation component of slope. The articles cited herein are presented in Table 5 below in chronological order of publication. The table also illustrates the diagnoses of the populations included in these literature reports.

**Table 5. Components of intonation focused on in studies**

|                         | <i>Pitch control</i> | <i>Fundamental frequency</i> | <i>F<sub>0</sub> variability or range</i> | <i>Diagnosis</i>           |
|-------------------------|----------------------|------------------------------|---|----------------------------|
| Darrow & Starmer (1986) | ✓                    | ✓                            | ✓   | Hearing Impairment         |
| Lucia (1987)            | ✓                    |                              | ✓   | TBI                        |
| Zoller (1991)           | ✓                    |                              | ✓   | Intellectual Disability    |
| Darrow & Cohen (1991)   | ✓                    | ✓                            | ✓   | Hearing Impairment         |
| Cohen (1992)            |                      | ✓                            | ✓   | CVA                        |
| Cohen & Masse (1993)    | ✓                    |                              | ✓   | CVA, Neurological diseases |
| Cohen (1995)            |                      |                              | ✓   | CVA                        |
| Livingston (1996)       | ✓                    |                              | ✓   | TBI                        |
| Aigen (1998)            |                      | ✓                            | ✓   | Intellectual Disability    |
| Newham (1998)           |                      |                              | ✓   | Psychological Problem      |
| Magee (1999a)           |                      |                              | ✓   | Neurological diseases      |
| Kennelly et al., (2001) | ✓                    |                              | ✓   | TBI                        |
| Haneishi (2001)         |                      | ✓                            | ✓   | Neurological diseases      |

*Note:* CVA = Cerebral Vascular Accident

Table 5 illustrates that all studies focused on the F<sub>0</sub> Variability and range. Further, TBI and cerebral vascular accidents were the most commonly reported diagnosis in the literature suggesting its acceptance that music therapy has a role to play in alleviating impairment in intonation and pitch control with this population.

Comparing these studies and reports is problematic because most of the studies did not state the specific site of lesion or pathology, the prognosis for recovery, age of the subjects and the length of time since the trauma or medical incident occurred. Those studies that did provide adequate information on subjects' backgrounds included non-homogenous groups of subjects. For example, Cohen (1992) included six experimental subjects who displayed apraxia, dysarthria or Broca's aphasia with a range of differing aetiologies (non-homogenous), which raises questions regarding the influence of these variables on her results. Non-homogenous groups were also found in the study by Cohen & Masse (1993) (cerebral vascular accident, multiple sclerosis, cerebral palsy, and

Parkinson's Disease). These weaknesses are often unavoidable in studies with people who have brain injury due to the highly individualised nature of lesions and the limited number of people available to participate in a study at any point in time. Therefore, much of the following presentation must be considered as suggesting trends rather than absolute findings. In another respect, perhaps the similar positive outcomes obtained across these differing pathologies in Cohen's (1992) and Cohen & Masse's (1993) studies suggests that the treatment had some standardised effect.

### 3.1.2 Therapy outcomes

Comparing outcomes and outcome measures between literature reports was problematic because so few reports were experimental studies. Lucia (1987) does not even refer to outcomes, only describing her program implementation protocol. Cohen & Masse (1993), Kennelly et al. (2001), Aigen (1998) and Magee (1999a) all reported anecdotal improvements in different aspects of vocal functioning. Rigorous measures of outcome evaluation were undertaken by a few authors although most of these were case studies and not experimental studies.

Darrow & Starmer (1986) examined the effect of music therapy on the  $F_0$  and the  $F_0$  range in children with hearing impairments. Syntactically different speech samples (questions and statements) were fed through the Kay Elemetrics software program Visi-Pitch™ (Model 6087A) to analyse the  $F_0$  and the  $F_0$  range. The results were significant for both intonation components with the  $F_0$  decreasing from pre- to post-test ( $p < .01$ ) and the  $F_0$  range increasing from pre- to post-test ( $p < .05$ ).

In a case study of a hearing-impaired girl reported by Darrow & Cohen (1991), improvement in the ability to reproduce a given pitch or pitch pattern was tested using Pitch Master, a device measuring the pitch accuracy of sung notes against a given target. When outcomes were measured, the girl made significant improvements between the pre-test and the post-test ( $p = .05$ ). Similarly, in their second case, Darrow & Cohen (1991) assessed changes to pitch control pre- and post-program in a girl with hearing impairment. Test descriptors were not described. An unspecified number of raters assessed accuracy in pitch control (interrater-reliability = .88) and found that post-test measures improved by 26% in one test, and 49% in the second. Although levels of significance were not established, improvements were noted.

In people with neurological damage, Cohen (1992) assessed changes to the  $F_0$  and the  $F_0$  variability (in semitones) following a group singing instruction program. In

assessing the subjects' progress, she fed audio samples through a specialised computer program - Sono-graph™ (model 5500, Kay Elemetrics). She found that two subjects increased their  $F_0$  and four decreased their  $F_0$  following treatment. The two control participants also decreased their  $F_0$ . Similarly, only three of the six experimental subjects increased their  $F_0$  variability (which increased by a mean of 6.53 semitones). The important finding in Cohen's study was that subjects responded in idiosyncratic ways, which may relate to the non-homogeneity of both the experimental and group.

Cohen's (1995) report of two cases of subjects with neurological impairments is useful because it provides data on each treatment session so that the trends in recovery can be studied more closely. Her subjects participated in weekly vocal instruction and they also were required to practice at home using cassette tapes supplied by Cohen. She states that audio samples were collected weekly but it is not clear from this report whether these were collected during the treatment sessions, or pre or post-session. Further, the content of this audio material was not mentioned, i.e. whether the content was material read aloud by the subjects or part of spontaneous speech. The audio samples were analysed using Visi-Pitch™ software but no substantial changes in the  $F_0$  range were evident in either of the two neurologically impaired subjects despite improvements in voice volume, appropriate speech rate and improved verbal intelligibility being found. What was noticeable in Cohen's cases was the high variability in responses from session to session with regard to the  $F_0$  range, particularly in the second case where at one point the subject's range increased from about 500Hz to over 600Hz and then approximately 450Hz in three consecutive treatment sessions. Finally, it is noticeable in her first case that the  $F_0$  range in session one was 130Hz, which dropped to about 95Hz in the next session and did not increase beyond 100Hz for the remainder of the program. This response might suggest that Cohen's subject intentionally tried hard to use a large  $F_0$  range and in the process, over-exaggerated his speaking contour. As with Cohen's (1992) study, these two cases highlight the individualistic ways subjects respond to treatment.

One case vignette reported by Livingston (1996) described the use of subjective perceptual measures<sup>8</sup> (semitones) to assess increases in singing pitch range of a woman with TBI (RHD). Outcomes showed vocal range increases from one to 18 semitones within a six-month treatment period. Carry-over to speech was noticed after nine months but the

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<sup>8</sup> The term subjective perceptual measure is used to describe quantified data that has been collected from subjective perceptual means. In this case, semitone range was determined by the subjective assessment of the author who identified perceptually the notes sung by the woman which was later calculated into a semitone range.



details as to how this was assessed were omitted from the report. As Livingston's client was eight-years post-injury, this outcome was regarded as significant, with spontaneous recovery unlikely a factor. Subjective perceptual measures were also adopted by Newham (1998) to assess vocal range in a woman who presented with a monotone voice arising from psychological problems. His interventions enabled her to increase her vocal range by one and a half octaves.

Finally, Haneishi (2001) worked with Parkinson's disease subjects to improve their  $F_0$ ,  $F_0$  variability and voice range. Subjects read the *Rainbow Passage* and their audio samples analysed through the Multi-Speech™ software program. Like Cohen (1995), he collected data pre- and post-session (immediate effects of treatment) and pre- and post-program (long term effects of treatment). Significant long-term effects were only found for the  $F_0$  ( $p = .058$ ). The data reported by Haneishi allowed for the following calculation of effect sizes to be computed and these are reported in Table 6 below.

**Table 6. Effect sizes in Haneishi's (2001) study**

| Variable                          | Immediate effect                       | Long term effect |
|-----------------------------------|--|------------------|
| Fundamental Frequency             | $d = 0.28$                             | $d = 1.53$       |
| Fundamental Frequency Variability | $d = 0.24$                             | $d = 0.10$       |
| Voice Range                       | No data available for this calculation | $d = 0.91$       |

The immediate effects for both the immediate and long term changes to  $F_0$  variability are small and the immediate effect for  $F_0$  is also small. The long term effect sizes for the  $F_0$  and voice range are very large and it would be highly likely that these would lead to levels of significance in a study with larger numbers of subjects.

Several discrepancies were evident in the findings reported here. Some studies noted no changes in the  $F_0$  (Cohen, 1995), some found increases in the  $F_0$  (Haneishi, 2001), while others noted a decrease in the  $F_0$  (Darrow & Starmer, 1986). Cohen (1992) reported that some of her subjects increased their  $F_0$  while others decreased. The  $F_0$  variability increased in all studies reported (Cohen, 1992; Darrow & Starmer, 1986; Haneishi, 2001)

although in Cohen's study, only half of the experimental group displayed increases in  $F_0$  variability.

The literature reported here supports the application of music therapy programs in increasing pitch control and  $F_0$  variability range regardless of pathology. Therefore, some broad generalisations can be made regarding expected improvements in these areas for all populations presenting with these impairments. Discrepancies in the  $F_0$  outcomes suggest that further research is required until more conclusive evidence for music therapy's effect on this variable has been realised. It is unclear why these discrepancies have occurred but it is likely that lesion location may play a factor in predicting therapeutic outcomes because the pathology of subjects both between and within studies varies significantly.

### **3.2 Music therapy interventions adopted**

Various music therapy interventions have been adopted to address intonation impairments. These interventions include song singing, performing vocal exercises, playing wind instruments, improvisation, and auditory and non-auditory strategies. The studies using these techniques are summarised in Table 7 below.

**Table 7. Interventions employed in treating intonation impairments**

|  | <i>Song<br/>singing</i> | <i>Vocal<br/>exercises</i> | <i>Non-auditory<br/>feedback</i> | <i>Auditory<br/>feedback</i> | <i>Impro-<br/>visation</i> |
|--|-------------------------|----------------------------|----------------------------------|------------------------------|----------------------------|
| Darrow & Starmer (1986)                  | ✓                       | ✓                          | ✓                                |                              |                            |
| Lucia (1987)                             | ✓                       | ✓                          |                                  |                              |                            |
| Cohen (1991)                             | ✓                       | ✓                          |                                  | ✓                            |                            |
| Zoller (1991)                            |                         |                            | ✓                                |                              |                            |
| Darrow & Cohen (1991)                    | ✓                       | ✓                          | ✓                                |                              |                            |
| Cohen (1992)                             | ✓                       | ✓                          |                                  | ✓                            |                            |
| Cohen & Masse (1993)                     | ✓                       | ✓                          |                                  |                              |                            |
| Cohen (1995)                             | ✓                       | ✓                          | ✓                                |                              |                            |
| Livingston (1996)                        | ✓                       | ✓                          |                                  |                              |                            |
| Aigen (1998)                             |                         |                            |                                  |                              | ✓                          |
| Newham (1998)                            |                         |                            |                                  |                              |                            |
| Magee (1999a)                            |                         |                            |                                  |                              | ✓                          |
| Kennelly et al. (2001)                   | ✓                       |                            | ✓                                |                              |                            |
| Haneishi (2001)                          | ✓                       | ✓                          |                                  | ✓                            |                            |
| Percentage of Total Number of<br>Studies | 71%                     | 64%                        | 36%                              | 21%                          | 14%                        |

Table 7 shows that the combination of song singing and vocal exercises were the most commonly employed techniques. Non-auditory feedback techniques were used infrequently, again, mostly in combination with singing and/or vocal exercises. Auditory feedback was seldom used for addressing impairment of intonation and more frequently employed for treating impairments in speaking rate (Cohen, 1988; Cohen & Masse, 1993; Livingston, 1996; Lucia, 1987). Improvisation was only cited in two studies.

### 3.2.1 Song singing

All the literature cited in Table 7 that adopted song singing as a part or all of the treatment, included the singing of familiar songs either selected for the subjects or subject-selected (Cohen, 1992; Cohen & Masse, 1993; Livingston, 1996). Although not discussed in the articles, the frequent inclusion of familiar music may be explained firstly because it can evoke automatic singing responses, therefore bypassing conscious control (Baker,

2000). Automatic responses enable subjects to sing the melody and lyrics easily and in doing so, reduce the level of concentration required for the task. This may leave the subjects with sufficient possibilities to focus on the actual accuracy of their singing – the control of pitch. This is particularly important for people with TBI who are predisposed to fatigue. Perhaps the automatic singing response associated with familiar songs provides them with less mentally demanding tasks than singing unfamiliar tasks. Therefore, it could be assumed that the subjects participate in singing for longer periods prior to fatigue when singing familiar songs than when singing unfamiliar songs. This has not been explored in the research literature and is worthy of investigation.

Further, the inclusion of familiar music can be explained in that it is more recognisable and therefore more motivating than non-familiar or improvised music. Participating in therapy can be difficult and adding the enjoyable medium of music may enable subjects to participate for longer periods.

Cohen (1991) described her song selection criteria according to the musical characteristics used. The songs selected featured melodic or rhythmic repetition, moderate tempi, simple rhythms, diatonic or pentatonic melody lines, homophonic, syllabic settings, triadic harmony structure which enhanced melody, a maximum vocal range of one octave, medium range tessitura and strophic form (p.64). Although not discussed by Cohen, these criteria indicate that she selected songs that were predictable and easy to follow. Such predictability eliminates the thought required to engage with unfamiliar (or unpredictable) music, thereby freeing cognitive pathways for full concentration on developing the required skill. Further discussions on song singing's suitability in addressing intonation impairments are discussed later in this chapter.

### **3.2.2 Vocal exercises**

As listed in Table 7 earlier, vocal exercises have been employed to facilitate the reacquisition of pitch control, appropriate  $F_0$ ,  $F_0$  variability and  $F_0$  range. In some citings vocal exercises functioned as a vocal warm-up prior to song singing activities and in others it functioned as the key or sole tool in addressing the impairment. Table 8 below illustrates the percentage of treatment time devoted to vocal exercises in relation to song singing.

**Table 8. Proportion of programs designated to vocal exercises**

|                         | <i>Breathing exercises</i> | <i>Vocal exercises</i> | <i>Song singing</i> |
|-------------------------|----------------------------|------------------------|---------------------|
| Darrow & Starmer (1986) |                            | 50% of time            | 50% of time         |
| Cohen & Masse (1993)    | 5 minutes                  | 15 minutes (50%)       | 10 minutes          |
| Cohen (1995)            | 10 minutes                 | 30 minutes (60%)       | 10 minutes          |
| Haneishi (2001)         |                            | 50% of time            | 50% of time         |

*Note:* that Cohen 1992, Darrow & Cohen (1991) and Lucia (1987) did not state the proportion of time allocated to these two activities.

Table 8 highlights that all the studies devoted at least 50% of the session time to vocal exercises and illustrates the importance placed on these tasks in the rehabilitation programs. Cohen (1995) places particular importance to the employment of vocal exercises where 30 minutes of a 50-minute session was designated to vocal exercises.

The vocal exercises devised by Haneishi (2001) were the most clearly described of all those cited in the literature and included singing scale patterns. Lucia (1987) outlined two exercises that she used in her program - the singing of pentatonic scale patterns, and the second was the singing of 1-3-5-3-1 patterns (Figure 1).

**Figure 1. Example of singing exercise (Lucia, 1987)**

Cohen (1995) and Cohen & Masse (1993) described their exercises as similar to those employed in Melodic Intonation Therapy (Sparks and Helm, 1973). Mono- or multi-syllabic words were set to descending or ascending melodic patterns containing the rhythm of the words. The range of pitches used was slightly larger than what is present in normal speech intonation. Perhaps the rationale behind this concept was that by exaggerating the intonation pattern, the subjects' vocal flexibility would improve.

Physical warm-ups preceded any singing in Lucia's (1987), Cohen's (1991; 1992) and Haneishi's (2001) programs. Such exercises included facial massage, breathing exercises, and a series of neck, head and upper trunk relaxation exercises. Cohen (1991)

argued that vocal warm-ups increased subjects' awareness of correct diaphragmatic breathing in order to improve the  $F_0$  variability.

The importance placed on *exercise* seems to ignore the concept that the voice is an expressive instrument of the body. What might be necessary for these subjects are not exercises in vocal technique (like a singer rehearsing vocal technical exercises) but experience in vocally expressing emotions – something that may be achieved in song singing.

### 3.2.3 Auditory and non-auditory feedback strategies

Singing in combination with non-auditory feedback tools has been trialled by Cohen (1995), Darrow & Cohen (1991), Darrow & Starmer (1986), Kennelly et al. (2001) and Zoller (1991). As with the speech pathology interventions described in chapter 2, non-auditory feedback strategies are visual and/or tactile experiences that augment the music therapy treatment.

Darrow & Starmer (1986) used kinaesthetic feedback techniques to improve the vocal control of hearing-impaired children. Here, children were asked to feel the vibration of their vocal folds by touching their throats. Although not trialled with people who have TBI, this *concrete* technique might also be suitable.

Zoller (1991), Darrow & Cohen (1991), and Kennelly et al. (2001) adopted solfeggio syllables and the corresponding hand signs, to accompany vocal exercises. Here, the visual cue of changing hand height is framed to represent changing pitch height (Darrow & Starmer, 1991). This technique provides very concrete cues for the direction and degree of vocal pitch change.

Cohen (1995) used Visi-Pitch™ (Kay Elemetrics) to provide her subjects with immediate visual and statistical feedback on their  $F_0$  and  $F_0$  range. Visi-Pitch™, a computer software program designed to provide graphical and numerical analysis of vocal characteristics in real time, functioned as a biofeedback mechanism, allowing subjects to visually monitor their performance. Cohen (1995) found that the combination of Visi-Pitch™ and music therapy did not consistently increase  $F_0$  and  $F_0$  range. However, it did assist in enhancing speaking rate and intensity. Perhaps the lack of consistent improvements was the result of subjects having too many aspects of treatment to focus on simultaneously. Attempting to simultaneously monitor and modify the  $F_0$ ,  $F_0$  range, speaking rate and vocal intensity, demands too much from a person with TBI.

Reports on the use of auditory feedback strategies to facilitate improvements in intonation have been limited to two studies by Cohen (1992) and Cohen & Masse (1993). Both these studies successfully employed melodic cues by inserting melodic phrasing into various sentences.

The inclusion of auditory and non-auditory strategies into music therapy programs designed for reducing intonation impairments show that multi-sensorial experiences are beneficial. However, like other areas of music therapy, research into these interventions is in its infancy. It is not clear which auditory and non-auditory techniques are the most effective or how the skills developed in the therapy session transferred to speaking intonation. Further research would help to clarify these issues.

### **3.2.4 Improvisation interventions**

Vocal improvisation has been advocated when the full expressive potential of the voice has been inhibited. This approach stems from the notion that mood, emotional integration and creativity, pervade many areas of human functioning, one of which is the voice. If music improvisation is capable of enhancing mood, emotional integration and creativity, then it is possible that vocal freeness will follow.

Newham (1998) and Aigen (1998) embrace improvisational method to enhance the subjects' mood and emotional integration and develop their creativity. One of Aigen's (1998) case studies exemplifies this concept. Through instrumental improvisation, he increased the girl's creativity, flexibility and reduced her rigidity. He considered her vocal rigidity and flatness as symptomatic of a more global problem. In addressing the global problem, he facilitated change in other areas of the girl's functioning (including her vocal skills).

Conversely, Magee (1999a) used vocal improvisation to facilitate functional goals of a man with severe brain injury. Functional goals included vocalisation (including pitch control) and redeveloping verbal sounds. In this case, these functional goals were not achieved however there were other benefits from the program such as improved social interaction. Magee suggested that perhaps targeting functional goals with such impaired people may not be of benefit.

The reports by Newham (1998), Magee (1999a) and Aigen (1998) are anecdotal and subjective. Reliability and validity of these results are uncertain and further research in this area is warranted. Research on the use of improvisation to address

intonation impairments with people who have TBI is yet to be undertaken. However, the abstract and unfamiliar nature of improvisation may not have the same impact for this population as it has for the people in Newham's (1998), Magee's (1999a) and Aigen's (1998) reports.

### 3.3 Frequency and length of program

Providing the optimum session length, program length and frequency of sessions is vital when implementing programs for people in the early-to-recover stages of TBI. No study has specifically studied the influence of these factors but many studies cited previously have given mention to session length and frequency, and program length (Table 9).

**Table 9. Summary of session duration, frequency and program length**

|                         | <i>Session duration</i> | <i>Session frequency</i> | <i>Program length</i> |
|-------------------------|-------------------------|--------------------------|-----------------------|
| Darrow & Starmer (1986) |                         | 2 x week                 | 8 weeks               |
| Lucia (1987)            | 40 minutes              | 3 x week                 |                       |
| Darrow & Cohen (1991)   |                         | daily                    | 6 weeks, 3 months     |
| Cohen 1992              | 30 minutes              | 3 x week                 | 3 weeks               |
| Cohen (1995)            | 50 minutes              | 1 x week                 | 10 weeks              |
| Haneishi (2001)         | 60 minutes              | 3 x week                 | 6 to 7 weeks          |

Table 9 shows that session lengths employed were between 30 and 60 minutes duration. In Cohen's (1995) study, no substantial changes in the  $F_0$  range were recorded when sessions were of 50 minutes duration (40 minutes of vocal exercises, 10 minutes of singing). Similarly, Haneishi (2001) found no significant immediate changes in  $F_0$  and  $F_0$  variability from sessions of 60 minutes duration (long term effects approached significance for  $F_0$ ). Perhaps fatigue was an influencing factor here, the subjects unable to demonstrate improvements due to reduced energy levels. Conversely, positive outcomes were obtained in Cohen's (1992) and Lucia's (1987) reports where sessions were 30 minutes and 40 minutes duration. Despite inconsistencies in session length and outcomes, these reports



point to the general acceptance that sessions should be between 30 and 60 minutes in duration.

The summary presented in Table 9 also highlights that programs were between three weeks and three months in length with sessions scheduled from anything between one and seven times weekly. In children with hearing impairment, Darrow & Cohen (1991) showed how programs need to be tailored to the individual child's needs - one subject improved pitch matching ability following six weeks of daily music therapy while another required three months of weekly sessions. Darrow & Starmer (1986) reported that twice-weekly sessions for eight weeks significantly improved changes to  $F_0$  ( $p < .01$ ) and  $F_0$  range ( $p < .05$ ) in children with hearing impairment. For patients with Parkinson's disease, intense treatment (three times weekly) over six or seven weeks did facilitate improvements in  $F_0$  to near levels of significance ( $p = .058$ ) but not for  $F_0$  variability.

Cohen (1992) found that between seven and nine sessions over a three-week period was sufficient to facilitate improvements in intonation in some of her subjects with TBI. However insignificant results were found for Cohen's (1995) case studies where once-weekly sessions for ten consecutive weeks were employed. Perhaps these findings indicate that ideally, a minimum of two to three sessions a week achieves the fastest and greatest improvement in intonation function in people with TBI. As for the duration of the program, the studies indicate that seven to ten weeks of treatment is warranted.

For people with TBI, the appropriate of length of session, their frequency and the duration of the program are influenced by subjects' rate of recovery, this being a function of lesion sites sustained, time since trauma and severity of injury. However most studies were thin on such details (Cohen, 1992). Cohen (1992) controlled for the effect of the normal curve of recovery (by including two subjects as controls), but she did not mention how long post-injury the subjects were, their length of coma or the severity of their brain injury. Further studies should communicate this background material as it may contribute to establishing the appropriate length, duration and frequency of treatment sessions.

The research studies and case studies presented point to the benefits of frequent sessions over a short time frame rather than infrequent sessions over longer time frames. This is not surprising given that functional recovery tends to be largest early in the rehabilitation process. Frequent interventions capitalise on the most critical period – early intervention, and provide the necessary continuous support to push client progress forward rather than perhaps remaining at a stationary or maintenance point (which may occur if time between sessions is too long). However these findings should not be over-interpreted

given that no study has specifically studied the influence of such factors on the rate or degree of functional outcome.

### **3.4 Group therapy and individual therapy**

The appropriateness of group or individual music therapy sessions for rehabilitating intonation functioning is also a debate worthy of discussion. Significant improvements were established following group music therapy programs in the studies by Darrow & Starmer (1986) and Cohen (1992). These authors did not state the rationale for adopting group music therapy methods.

In comparison, Cohen (1995), Darrow & Cohen (1991), Kennelly et al. (2001), Livingston (1996), Magee, (1999a), and Aigen (1998), all provided individual therapy programs. Improvements in intonation components were found by Livingston (1996) and Kennelly et al. (2001). Cohen (1995) found improvements in some areas of her study but not in intonation. It is unclear from Magee's (1999a) and Aigen's (1998) work whether their clients made improvements that would be considered significant.

It appears that both group and individual music therapy programs can be beneficial in facilitating improvements in intonation. However, because no studies have compared the participation of subjects in groups against those receiving music therapy individually, it is unclear as to which medium is the most effective. In her 1992 study, Cohen raised the question regarding the appropriateness of group singing in contrast to individual singing. She suggests that individual singing can limit a subject's performance due to anxiety of singing solo. However, she also acknowledges that group singing may be confronting for some subjects, perhaps when they have insight to their impaired intonation, thereby becoming self-conscious about singing in front of others.

Although not discussed in the studies, individual sessions allow for the programs to be individually tailored. This would be recommended for people with TBI who present with a range of different clinical problems and a range of musical interests. Individualised therapy would allow the therapist to modify the program according to the changing needs of the person which is more difficult within the group setting. Further, forming a group with people who have similar a similar clinical presentation, and who are available for therapy sessions at the same time, may be difficult.

## Conclusion

The research cited points to the possibility that singing may be a viable intervention to treat disorders of intonation given the frequency that it has been adopted in the cited literature. Studies have shown that pitch control, the  $F_0$ , the  $F_0$  variability and the  $F_0$  range have been successfully enhanced following such interventions. The literature reviewed also points to the notion that short and intense treatment programs are of most value.

The literature highlighted that vocal exercises were adopted jointly with song singing and never in isolation. Perhaps the employment of song singing was in many cases included to distract subjects, to increase their engagement in therapy, and to practice skills learnt in the exercises in a different context. The description of both the use of auditory and non-auditory feedback cues in the treatment of voice disorders also provide good groundings for future investigations into this area. It is clear that further research concerning improvisation as a method in treating intonation impairment is recommended. However it is questionable whether such a technique is understandable to people with TBI and maybe better suited to other populations.

## 3.5 Speech and song: The similarities and differences

*“Comparisons between music and language are promoted by the strong similarities between the two. Both have an inherent structure and evolve over a temporal continuum, both have a meaning for the listener, and are innate expressions of human capacities. In music and language there is a phonetic, a syntactic, and a semantic level.” (Aiello, 1994, p.40).*

It was established earlier in this chapter that song singing was frequently employed when people presented with impairments in intonation suggesting that music therapists and researchers afford much of the positive effects yielded to the use of songs. Given this, then it is probable that both song singing and intonation share some common features, an area of interest among musicologists, philosophers, anthropologists, linguists, speech pathologists and music therapists (for example: Aiello, 1994; Borchgrevink, 1982; 1991; Brown, 2000; Dowling, 1995; Henson, 1977; Jackendoff & Lerdahl, 1982; Klinger & Peter, 1962; Langer, 1956; Molino, 2000; Patel et al., 1998; Pierrehumbert, 1991; Rischel, 1991; Scherer, 1991; Sundberg, 1982).

Although there are many similarities between language and music both in structure, function, evolution and metaphor, it is not possible to present philosophical discussions on

all of these areas. Concepts such as the metaphor that “music is a language” have been omitted as they are not regarded as necessary to understanding the questions posed in this thesis. While the focus of the following discussion compares song melody and intonation, often the literature referred to music and language on broader levels. This has been included to provide a stronger frame for establishing a link between song-melody and intonation.

Aiello (1994) states that melody in song and intonation are related even at the level of definition with the word *melody* being derived from the concept of a “musical intonation of a spoken phrase” (p.43). The singing styles of recitative, Sprechstimme and Sprechgesang are particularly vivid examples of how intonation and Western song-melody can be fused (Henson, 1977). In Sprechgesang (or speech song), singing is tinged with speaking quality and in Sprechstimme (or speech voice), speech is tinged with a singing quality. Brown (2000) develops this idea further suggesting that speech and music are related but on opposite points on a continuous spectrum, with heightened speech such as rap music, sprechstimme, sprechgesang, recitative, and poetic meter falling towards the speech side of the spectrum and aria and songs, falling closer to the music side of the spectrum. Because of this relationship, there is a solid foundation for arguing that the use of song-phrases (on the musical end of the spectrum) redevelops expressive potential in those people where intonation impairment is evident (on the speech end of the spectrum).

At the structural level, both intonation and song-phrases utilise structured patterns of pitch (melody), duration (rhythm) and intensity (dynamics) (Patel et al., 1998), indicating the existence of a relationship. However, Brown (2000) states that their use in these two mediums varies and depends on their function at any one time - intonation makes use of melody, rhythm and dynamics to convey both linguistic and affective meaning whereas the construction of song-melody is guided by emotion and meaning at a more global level. In this respect, an improvement in musical expression may not carry over to enhanced expression in intonation given that they manipulate the same melody components for different purposes.

Similarities in contour and melodic shape exist between song-phrases and intonation. Vocal pitch tends to rise at the beginning and fall at the end of phrases (Bolinger, 1986; Peretz, 1990). Similarly, melodic contour conveys tension and tension-resolution in intonation and in music. Brown (2000) further extrapolates this similarity by stating that universal melodies exist for both intonation and song-phrases (Western music). Question phrases (ascending contours) convey feelings of tension and uncertainty, whereas

answer phrases (descending contours) convey the resolution of that uncertainty. An assumption might be made that increasing people's ability to follow the melodic contours of songs (which have clearer and more exaggerated structures than intonation), may influence their ability to use the same intonation contours during speaking.

A review of the research by Brown (2000) found that like music, the majority of the world's languages are tonal and that intonation patterns reflect emotion through changes in tonality - major keys reflect happiness and minor keys reflect sadness (Murray and Arnott, 1993). However, Rischel (1991) identified that the primary differences between the two exist in the way pitch is used. Rischel said that music utilised well-defined intervals that are expressed as ratios of fundamental frequencies and belonged to a certain scale, whereas melodies in intonation are not necessarily linked to absolute pitches.

In contrast, Bolinger (1986) found that intonation and song-melodies share the use of some of the same intervals - monotones, octaves, 5<sup>th</sup>, 4<sup>th</sup> and 3<sup>rd</sup>. For example, the exclamation adopts an upward interval approximating a major 3<sup>rd</sup>. These are heard in phrases such as *She did?*, *It is?*, *Really?*. This finding might imply that developing people's vocal repertoire of different intervals (through singing), may lead to the development of a repertoire of intervals that can be used during speaking. What Bolinger (1986; 1989) or other authors have not discussed is whether the affect created by these intervals is the same in both intonation and song-phrases. It is possible that they may contradict one another. For example, perhaps a rising major 3<sup>rd</sup> used during speaking may affect a listener differently than a major 3<sup>rd</sup> used during a vocal improvisation. If this were the case, then the transfer of skills from song singing to intonation may be contraindicated.

Another similarity between speech and song-phrases is that they are both built on a finite series of basic units (Bickerton, 2000; Brown, 2000; Henson, 1977; Molino, 2000; Pierrehumbert, 1991; Richman, 2000; Todd, 2000). In speech, the basic are phonemes, syllables and words placed at varying pitch heights, durations and levels of intensity. In music the basic units are tones and intervals placed at various pitch registers, intensity levels and duration levels. Richman (2000) proposed that these building blocks are selected, combined and arranged to create phrases in speech and to create song-phrases in music. He argued that people know, store, remember, have access to, and produce these formulas as holistic, independent, and highly idiosyncratic entities and that they become automatic based on repetition.

In light of Richman's (2000) views, it is possible that by expanding the number of different intervals that can be produced, more units will be available to select, combine and

arrange to form differing intonation patterns. However, improvements in the ability to manipulate and control pitch does not necessarily lead to its appropriate use in affective communication. Several authors highlight that rules apply to both music and intonation and when appropriately used, can express a range of emotions (Bickerton, 2000; Dowling, 1995; Pierrehumbert, 1991). It does not necessarily follow that the rules that govern how intervals are used in song-phrases and in intonation are interchangeable.

In contrast, Brown (2000), states that once constructed, intonation patterns and melodies in song are varied and modified to convey or emphasise emotional state and emotive meaning. Small modulations in tempo (*accelerando*, *ritardando*), pitch (ascending, descending), volume (*crescendo*, *decrescendo*, *sforzando*) and length (*ritenuto*), convey emphasis, emotional state and emotional meaning during speech and during music (Brown, 2000; Pierrehumbert, 1991).<sup>9</sup> For example, music and intonation convey happiness through fast tempos, large amplitude sounds, and high registers (Brown, 2000; Murray & Arnott, 1993). To relate this point to the present thesis, it might mean that people's abilities to modulate pitch during singing and intonation are somehow related. If this is the case, one might predict that an improvement in the ability to alter pitch in singing may correlate with an improvement in the ability to alter pitch in intonation.

The establishment of a common evolutionary origin of music and language (including intonation) may provide a basis for why song singing may assist in rehabilitating intonation following neurological damage. Brown (2000) advocates the existence of a model – *the musilanguage model* – whereby music and language evolved from a single ancestral function that was a mixture of music and language. His argument stems from his observation that music and language have far too many commonalities to be coincidental. In the musilanguage model, the common properties of music and language evolved first, and the subsequent differentiating features evolved later. This model seems plausible as the boundaries of what is considered music and what is considered language is blurred (for example *Sprechstimme* and *Sprechgesang*). When do people consider themselves engaging in music and to what degree must they modify these activities to call them speech/language? His model supports the argument that singing has the potential to improve intonation.

Comparisons between intonation and song-phrases show that they share similarities in structure, function, and evolution. Such similarities include the use of intervals, the way

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<sup>9</sup> This is in conflict with the views of Bolinger (1986) and Sundberg (1982) presented earlier that music (pitch) is unable to be modified.

these intervals are selected and arranged together to form phrases, the modulation of these phrases to convey subtle differences in affect, the use of similar contours to convey tension and resolution, and the use of tonality to express affect. Such similarities suggest that singing and the production of intonation may share a common neural processing centre(s) and this is the next focus of discussion. However, it is important to restate that although similarities exist between the two areas, it is not clear whether the identical use of these various components produce the same affect in intonation and song-phrases. For example, consider whether the adoption of a certain interval within a song-phrase produces a different emotional effect on the listener than it does within a sentence.

### **3.6 Music therapy and neurological functioning**

The potential for singing to facilitate the rehabilitation of intonation can be understood from a neurological perspective. The localisation of music functioning and linguistic functioning has been a subject of discussion for many years, with contradictions in the literature the rule rather than the exception. The idea that music and speech are the result of separate neural processes or conversely share some common neural processing, has been the primary debate. The following section provides an overview of relevant literature to highlight such issues and to hypothesise why song singing has been found useful in activating recovery of intonation function. This supports the idea that intact musical functions could be used to facilitate neuroplastic changes in intonation. Due to the enormous body of literature in this area, a full description is not included here and discussions have been limited to the most relevant sources.

In many reported cases, people's ability to sing may remain intact despite having received lesions to the brain causing expressive language impairment (Baker, 2000; O'Callaghan, 1999; Sparks et al., 1974). One suggestion for why this occurs is that singing is associated with emotional responses, these being stored at a deep level, and relatively resilient to brain injury (Bunt, 1996). Peretz, Gagnon and Bouchard (1998) showed that extensive brain damage can spare emotional appreciation of music and that emotional responses to music appear to recruit brain circuitries that are particularly resistant to damage. This idea alludes that engagement in music activities (including singing) may be possible following brain injury due to the emotional involvement.

When focusing specifically on melody, Peretz (1990) and later Liégeois-Chauvel et al. (1998) found that the LH processes local information in melodies (intervals) and the RH is superior for dealing with global information (contour). This idea aligns with the *Split Brain Model* (cf. Hodges, 1996) where the two hemispheres assume conceptually two different functions - the LH is concerned with logical and analytical features and the RH dealing with holistic, spatial, non-verbal and intuitive features (Bunt, 1996). Peretz (1990) and Liégeois-Chauvel et al. (1998) found that LHD disrupts the neural circuitry for dealing with local features without simultaneously affecting the global melody representation of the RH. In contrast, when the RHD disrupts the processing system required for representing melody contour, it may affect the intact LH's necessary anchorage points for encoding local information. This indicates that RHD impaired the use of both interval and contour melodic information whereas LHD just impaired the interval processing. Therefore the RH may influence whether the LH processes can operate.<sup>10</sup> If facilitating improvements in intonation is the aim of therapy, singing would be a suitable intervention to adopt because song-phrases and intonation can activate both hemispheres.

Conversely, some research suggests that pitch in melody is processed only by the RH but melody itself activates both hemispheres because it also involves rhythm, a function controlled by the LH (Borchgrevink, 1982; Cohen & Ford, 1995; Kinsella, Prior, & Murray, 1988; Peretz & Herbert, 1995; Prior, Kinsella, & Giese, 1990; Shapiro, Grossman, & Gardner, 1981; and Zatorre, Evans, & Meyer, 1994). In extending this concept, Borchgrevink (1991) describes how melodies are often predominantly rhythmic or predominantly melodic and that this predominance influences the degree of hemispheric lateralisation. Therefore, different melodies would lead to different levels of engagement.<sup>11</sup> This theory also suggests that using song-phrases in treating intonation impairment would be useful because of its bilateral engagement. Perhaps more rhythmic melodies would be more useful in stimulating left hemisphere engagement if people have LHD and conversely, using more melodic phrases for those people who have more RHD.

To further support the idea that singing songs could involve the activation of both hemispheres, Zatorre (1984) found that the left hemisphere activates the actual act of singing and that good singing performance occurs only when both hemisphere are simultaneously active.

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<sup>10</sup> This finding parallels the Functionalist Hypothesis Model whereby the control of pitch in intonation within the LH and RH is dependent on its function – grammatical versus affective.

<sup>11</sup> Some melodies are rather monotonous with an easily recognisable rhythm, others are better recognised by their tonal characteristics.



Borchegevink (1991) provides another argument for why tapping into the music centres of the brain may be beneficial for people who have disorders of intonation. He suggests that in children, the musical centres of the brain may have initially controlled intonation and later lateralised to the speech-specific centres following their cognitive development. This concept might suggest that perhaps there is a possibility for intonation to be reactivated in the music centres if these remain intact following neurological trauma. Further investigation into this concept is warranted.

Patel et al. (1998) and Falk (2000) found that while music and intonation followed separate pathways, they shared many neurological underpinnings. First, the left primary auditory cortex and the prefrontal cortex played important roles in the retention and comparison of pitch patterns for music and intonation (Patel et al., 1998). Second, the same cortical regions of the left hemisphere are activated when listening to scales and listening to isolated words and when engaged in thoughtful speech (Falk, 2000). Third, Freeman (2000) states that participation in song singing involves the activation of the motor cortex, basal ganglia and cerebellum, and as discussed in Chapter 2, these regions are involved in the production of intonation. These findings support the idea that through music participation, some speech and/or intonation centres of the brain may be activated, this activation perhaps inadvertently reconnecting or reawakening the necessary neural systems utilised in intonation production.<sup>12</sup>

Davidson (1994) stated that the development of pitch relationships in children begins with the capacity to grasp the contour of a phrase. Following this, people develop the ability to match individual pitches. Finally, people develop an organising structure to maintain key stability across song-phrases. If this same process occurs in the reacquisition of pitch control following TBI, it might follow that people first master the melodic contour of songs, then the ability to match given note pitches. Given the argument that song-melody and intonation are related, perhaps improvement in song singing may parallel an improvement in intonation. At this stage, there have been no studies conducted to explore the redevelopment of pitch control in either singing or in intonation regardless of whether this is from spontaneous recovery or from recovery accelerated by treatment.

It is possible that people with TBI relearn to accurately sing intervals in the same way as children learn it for the first time. Dowling (1982) found that during singing, children first use melodic contours in a descending direction. According to Dowling,

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<sup>12</sup> The potential for music to stimulate neuroplastic processes has been discussed in an article submitted for publication by Baker and Roth.

contours develop from larger to smaller intervals. Children expand the boundaries of the tonal space first, then go back and fill in the gaps in previously acquired schemes with steps. For example, it is not until a child has acquired the ability to reliably sing a forth (as a leap) does he/she fill in the earlier leap (3<sup>rd</sup>) with stepwise motion. This back filling process continues until finally the contour scheme of a 6<sup>th</sup> has been achieved. At this point the process of development stops, and contour schemes do not continue to develop in the same way beyond the span of the 6<sup>th</sup>. Again, no study has examined the recovery in the control of pitch of people with TBI to establish if there is any correlation. However, it is conceivable that people with TBI may follow similar paths in reacquiring pitch control.

The literature presented here provide an argument for why song singing might be useful in facilitating improvements in speaking intonation. Neuromusicological literature have shown that intonation and song-phrases are processed in similar and in some cases, the same cortical regions. Typically these studies have examined the neuromusical aspects at a diagnostic level – establishing regions of the cortex responsible for various musical functions. However there is a distinctive lack of research into the way deficits in musical functions may recover and what corresponding cortical regions are subsequently activated when these musical functions recover. Research in this area is vital for understanding recovery of function as a consequence of music therapy treatment.

### **3.7 Singing as a vocal training exercise**

One potential reason why singing might enhance the vocal range, flexibility and intonation of people with brain injury is the possibility that singing develops vocal control in the same way as it does for people who are training to be singers. This section aims to describe the research conducted with singers and non-singers and the differences in vocal ability between the two groups.

Awan (1993) analysed the speaking  $F_0$  of young male and female singers and non-singers. Results indicated that there was no significant difference between the two groups. However, singers were found to exhibit significantly greater speaking  $F_0$  ranges than do non-singers. It was found that singers used 28-31% of their phonational range in speaking whereas non-singers used only 25%. These results provide evidence that those people who have been engaged in professional singing, have significantly greater flexibility in the use of their vocal range during speaking. This might suggest that singing could increase the  $F_0$  variability and range of people whose intonation has been impaired following TBI.

Similarly, no significant differences were found between singers and non-singers with respect to  $F_0$  in a study by Brown, Rothman, & Sapienza (2000). However, they concluded that it was unlikely that singers could be correctly identified from non-singers purely on the basis of the speaking voice.

Speaking  $F_0$  and  $F_0$  range of male singers and non-singers (Morris, Brown, Hick, & Howell, 1995) and female singers and non-singers (Brown, Morris, Hick, & Howell, 1993) were compared. Three age groups were examined (20-35 years, 40-55 years and 65+ years). In contrast to Awan (1993) and Brown et al. (2000), Morris et al. (1995) and Brown et al. (1993) found that the speaking  $F_0$  and range in the male and female groups were all higher in the three groups of singers but only significantly among the middle-aged group. These two studies suggest that for those people with below-normal  $F_0$  and  $F_0$  ranges, singing training could assist in raising these to more age-appropriate levels. Unfortunately the two studies did not examine  $F_0$  variability between the singer and non-singer groups.

When considering the issue of vocal control, Leonard et al. (1988) compared the pitch matching ability of singers and non-singers. Subjects were analysed in terms of accuracy, and the duration and speed in changing pitch. Singers were found to effect pitch changes in significantly less time than the non-singers, a finding attributed to their greater proficiency in controlling the vocal apparatus. Again, this supports the possibility that singing may help people to improve their vocal control so as to enhance their intonation functioning.

Although there are some discrepancies in the findings, the studies cited show that singers may have higher  $F_0$  and larger  $F_0$  ranges when compared with non-singers. Similarly, and not surprisingly, the singers also have greater accuracy and control over executing pitch changes. This suggests that singing develops the flexibility of the voice and increases its expressive potential. Therefore, singing may help to repair such functions if damaged by TBI.

### **3.8 Music and mood**

A premise previously discussed was that variations in mood affect the potential for the human voice to express emotion. It was shown that mood can directly affect the  $F_0$ , the  $F_0$  variability, the  $F_0$  range, and contour shape and slope (Table 1, p.29). It was also stated that for people with impairments in intonation following TBI, mood and emotional states could further exacerbate the problem. It may follow that an altered or enhanced mood

could directly influence intonation patterns. Music (and music therapy) has been a medium that has been shown to enhance mood with both clinical and non-clinical populations. Such outcomes suggest the potential benefits music may have in enhancing mood of people with TBI and in doing so, perhaps enhance their expressive intonation abilities. The following section presents an overview of the literature pertaining to music and mood to support this argument.

It is difficult to compare literature sources concerning music and mood because the terms mood, emotion, emotional responses and affect are used interchangeably and inconsistently by the same author and between different authors. According to Oatley (1989, cited Murray & Arnott, 1993, p.1097), emotions and emotional responses were defined as sudden responses to particular stimuli, the responses lasting only seconds or minutes. In comparison, moods were defined as more vague in nature, lasting for hours or days and affect refers to feelings or feeling states. While these distinctions are important, due to inconsistencies in the use of the terms in the reviewed research, and because people with TBI are susceptible to mood disturbances and extreme displays of emotional responses (particularly to stimuli which produces negative responses), for the purposes of this study the term mood has been adopted to include changes in mood for both short and long-term periods.

Table 10 describes how mood responses are displayed and measured in people, to aid the reader in the interpretation of mood responses to music. Many of these assessments have been used in the studies concerning music and mood.

**Table 10. Types of mood responses and measures (Spingte, 1991)**

| <i>Major category of mood assessment</i> | <i>Identification of mood states</i>   |
|--|--|
| Cognitive-Verbal                         | Standardised psychological tests   |
| Vegetative-Physiological                 | blood pressure, hormone levels, galvanic skin responses, electroencephalography, heart rate and respiration rate |
| Non-verbal, Psychomotor behaviour        | gestures, facial expression and behavioural patterns   |
| Self Reported Subjective Information     | Questionnaires, diary keeping  |

The majority of studies concerning music and mood states examined the cognitive-verbal responses and/or the vegetative-physiological responses. Conflicting findings were evident for the studies measuring physiological changes to mood and were often incongruent with self-reported and/or cognitive-verbal responses (Davis & Thaut, 1989; Iwanaga, Ikeda, & Iwaki, 1996; Robb, Nichols, Rutan, Bishop, & Parker, 1995). Reviewing this literature served no purpose in this thesis because of the inconsistent findings in physiological measures and because physiological measures were not adopted in this study's research method. However, research reports on the cognitive-verbal responses, psychomotor behavioural responses and self-report have yielded interesting and somewhat more consistent results.

There are numerous studies that examined the effect of music on the moods of non-clinical subjects (for example: Bonny, 1975; Davis & Thaut, 1989; Husain, Thompson, & Schellenberg, 2002; Iwanaga et al., 1996; Piagnatiello, Camp, Elder, & Raser, 1989, cited Kerr, Walsh, & Marshall, 2001, p.196; Robb, 2000; Stratton & Zalanowski, 1984; Thaut & Davis, 1993; Wheeler, 1985). The results of these studies point to the conclusion that music has the power to represent and to either elevate or depress mood states in people. The discrepancies in the findings related to the more specific aspects of how and what music actually evokes these responses. Such factors included the choice of music employed, the structural components of the music and the techniques used to employ the music (active versus passive listening), all of which will be later addressed in this section.

In comparison to the studies on non-clinical subjects, there are far fewer experimental studies documenting the effect of mood on clinical subjects (Burns, 2001; Haneishi, 2001; Hanser & Thompson, 1994; Kerr et al., 2001; MacNay, 1995; Magee & Davidson, 2002; Nayak, Wheeler, Shiflett, & Agostinelli, 2001; Robb et al., 1995; Strauser, 1997; Suzuki, 1998; Thaut, 1989; Waldon, 2001). This is not surprising given that many clients are unable to participate in the measurement activities involved in assessing mood due to impairments in cognition and communication. This notion is supported by the fact that the majority of the studies with clinical subjects were with people who were cognitively intact for example adults who had psychiatric disturbances or adults about to undergo medical procedures (Bonny, 1983; Kerr et al., 2001; Robb et al., 1995; Strauser, 1997; Thaut, 1989; Waldon, 2001). The general consensus was that music had the potential to enhance the mood of these subjects.

Three studies were found to have examined the effects of music therapy on the mood of people with neurological damage (Haneishi, 2001; Magee & Davidson, 2002;

Nayak et al., 2000). Nayak et al. (2000) studied people with TBI or stroke who participated in group music therapy sessions. Five different measures were used to identify a change in mood in the control group and experimental group – self-report, family report, therapist report, staff rating of therapy participation and family report on social interaction. The self-report measure comprised of *The Faces scale* (McDonald and Newell, 1996), which comprises of seven faces where the mouth varies from a full smile (upright semicircle) to a sad face (inverted semicircle). Music therapy groups using song singing, improvising, performing, composing and listening interventions were held two to three times per week for a maximum of ten sessions. The results showed that people in the music therapy treatment group were more social ( $p < .02$ ), more involved in therapy ( $p < .01$ ), and more motivated to participate in their rehabilitation programs ( $p = .06$ ) than the control group. Self-report measures indicated that there were no significant changes in mood ( $p = .10$ ). Family did report a positive change in mood in the previous 24-hours ( $p = .10$ ) and the previous week ( $p = .06$ ) but these improvements were not statistically significant. When effect sizes were calculated based on the figures reported in Nayak et al.'s study, larger effect sizes were found for the music therapy treatment group particularly for the self-report where the effect size was  $d = 1.05$  (and  $d = 0.79$  for the control group).

Haneishi (2001) examined the effect of a music therapy program on the immediate mood changes of patients with Parkinson's Disease. *The Feeling Scale* (Rejeski, Best, Griffith, & Kenny, 1987, cited Haneishi, 2001, p.283) which is a single bi-polar mood scale measuring from feeling very good (+5) to very bad (-5), was used to measure mood changes in response to a music therapy program that was designed primarily to enhance verbal communication. Haneishi found that mood improved from pre- to post-session however the difference was not large enough to be significant. Lack of significance was related to the small sample size ( $n = 4$ ) but when an effect size was calculated from the data presented in his report, a medium effect size was found ( $d = 0.51$ ).

Several important issues were addressed in a study by Magee & Davidson (2002). Fourteen participants with diagnoses of Multiple Sclerosis, TBI and cerebral vascular accident participated in two sessions of music therapy over a two-week period to determine the short-term effect of music therapy on mood states. Therapy comprised of one session of improvisation and one session of using pre-composed songs. A condensed version of the POMS-BI (Lorr & McNair, 1988 cited Magee & Davidson, 2002, p.23) was used to measure mood across four scales - composed-anxious, agreeable-hostile, energetic-tired, and elated-depressed. Significant decreases in anxiety ( $p = .01$ ), hostility ( $p = .003$ ), and

fatigue ( $p = .05$ ) were noted but no significant change in the depression-elation scale was found. The results also found that the use of improvisation and the use of songs were effective in facilitating mood change suggesting that type of intervention may not be an influencing factor. Magee & Davidson emphasise that the results have important implications for demonstrating music therapy's cost effectiveness by showing that mood change was evident in just two treatment sessions. However, Magee & Davidson also propose that longer-term treatment may be necessary to effect changes in the depressed-related scale and this warrants further inquiry.

Unlike the previous studies cited, Nayak et al. (2000), Haneishi (2001) and Magee & Davidson (2002), all used active forms of music therapy where the subjects engaged in active music making. Such interventions included the use of familiar song singing. Unwin, Kenny and Davis (2002) also studied the effects of active music making on the mood states of a group of non-clinical subjects who sang in a choir. They found that group singing decreased feelings of tension ( $p < .001$ ), anger ( $p < .001$ ), fatigue ( $p < .001$ ), and confusion ( $p < .001$ ). Such findings further support that active involvement in singing songs plays a role in modifying mood states. What was interesting in this study was that non-familiar songs with non-English texts were employed. Such non-familiarity and lack of cues contained in the lyrics would suggest that the musical components themselves are important in affecting mood states. It would have been interesting to have also studied the differences in mood responses during the singing of familiar and non-familiar songs. While non-familiar music may have this effect, it would not be appropriate for TBI people who require familiarity for feelings of safety (Ponsford et al., 1995)

In predicting what type of music would evoke mood responses, Hevner (1935; 1936; 1937; 1939) and Rigg (1940; 1941) studied the effects of different components of music on how people label music. The assumption here is that an "...emotional response is strongly related to the structural factors of a given musical stimuli..." (Abeles & Won Chung, 1996, p.310). Their seminal studies formed the foundation for future investigations. By only changing one element of music at a time (either rhythm, harmony, melodic structure, tonality, tempo etc), Hevner (1935; 1936; 1937; 1939) and Rigg (1940; 1941) demonstrated that certain characteristics of music could change people's perception of the moods portrayed in the music. Of all the musical components, tonality evoked the most clear-cut results with minor tonality evoking sad or dreamy moods and major tonality evoking happy moods. However, one point to raise here is that while the music may portray a certain emotion, it is not a given that it will affect the mood of the listener in this

way. This is discussed further on pages 75-77. Table 11 outlines the conclusions established from their studies.

**Table 11. Early established musical parameters affecting mood states**

| <i><b>Musical Component</b></i>  | <i><b>Mood State Portrayed</b></i>       |
|----------------------------------|--|
| Major tonality                   | happy, graceful, playful moods           |
| Minor tonality                   | sad, dreamy, sentimental moods           |
| Firm rhythms <sup>13</sup>       | vigorous and dignified moods             |
| Flowing rhythms                  | happy, graceful, dreamy and tender moods |
| Complex dissonant harmonies      | excitement, agitation, vigor or sadness  |
| Simple consonant harmonies       | happiness, grace, serenity               |
| Rising and falling melodic lines | no clear-cut, distinct or constant mood  |
| Slow tempos                      | dignity, calmness and sadness            |
| Fast tempos                      | restlessness and happiness               |
| High pitches                     | sprightly and humorous moods             |
| Low pitches                      | sadness, dignity and majesty             |
| Ascending 4ths in the melody     | joyful moods                             |
| Descending minor 2nds            | sadness                                  |

Both Hevner (1935, 1936; 1937; 1939) and Rigg (1940; 1941) instigated a new way of thinking how different elements of music can affect people's perceptions of the moods portrayed in them. However, the reality is that music is complex, it contains various combinations of elements and that these are often ever changing. Therefore, while Table 11 is useful in understanding how various elements of music may portray mood, music is rarely that simple and it is likely that one may fluctuate as the music progresses in describing the mood portrayed. Further, Rigg and Hevner both used classical pieces of music. Different findings may result when popular music styles of today are evaluated in this manner. Hevner (1935) also argued that while the findings were indicative of the expressiveness of the elements, these were only in relation to one another. For example, a major mode composition is not always *gay* and *playful* it is only *more gay* and *playful* than the same composition played in a minor key. Finally, there is an assumption by Hevner and

<sup>13</sup> Firm rhythms were those where a full chord sounded on the main beat.



Rigg music is generally and consistently expressive of mood. However, it is likely that people's perception of the mood of music may relate to their mood at the time (Wheeler, 1985) or their prior experience with music. These factors are described in more detail later in the chapter.

Studies have since replicated the findings for the major-happy and minor-sad associations (Crowder, 1984; Krumhansl, 1997; Radocy & Boyle, 1997; Scherer & Oshinsky, 1977), the fast tempo-happy and slow tempo-sad associations (Krumhansl, 1997), and the dissonance harmony-sad and consonant harmony-happy associations (Blood, Zatorre, Bermundez, & Evans, 1999; Krumhansl, 1997; Radocy & Boyle, 1997). However, there are conflicting findings with respect to rhythm and melodic direction. Scherer & Oshinsky (1977) recently found that complex rhythms where there are tones of many different durations were found to express happiness whereas sadness was conveyed by rhythms that were more regular. They also found that upward contours were indicative of fear and surprise and downward contours were indicative of sadness and boredom.

In a recent study, Juslin (1997) examined how different emotions were communicated during music performances of the same piece of music based on the four basic emotions referred to earlier (p.28). These are presented in Table 12.

**Table 12. Musical performance indicators and mood states (Juslin, 1997)**

| <i>Mood state</i> | <i>Performance indicators</i>                            |
|-------------------|--|
| <i>Anger</i>      | high sound levels, fast tempo and legato articulation    |
| <i>Sadness</i>    | slower tempos, legato, low sound level                   |
| <i>Happiness</i>  | fast tempos, high sound level, and staccato articulation |
| <i>Fear</i>       | low sound level, staccato articulation and slow tempo    |

Although alterations to melody were not described, differences in tempo actually affect the slope of a melody. Therefore, anger and happiness, which utilise fast tempos, create steeper slopes, as they are typical of intonation patterns reflecting the same mood states (p.29). Conversely, the slower tempos utilised for fear and sadness produce flatter slopes, and therefore mirror the flatter slopes characteristic of speech that expresses sadness or fear.<sup>14</sup> Krumhansl (1997) and Terwogt & van Grinsven (1991) concur with

<sup>14</sup> The author reminds the reader here that the intonation characteristics for afraid were inconclusive (p.29).

these findings. However, they also assert that while the difference between sad, happy and anger/fear are clear, the differentiation between angry and fear within music is not always so clear.

In 1980, Maher investigated the psychological effects of intervals. While not all the findings were conclusive, Maher found that the major 3<sup>rd</sup> is a happier sounding interval than the minor 3<sup>rd</sup>. He found that the 2<sup>nd</sup> was judged as more interesting, unstable, complex and restless than the octave; and the 2<sup>nd</sup> and 7<sup>th</sup> were more displeasing than the 5<sup>th</sup>. At present, no study has examined the use of different intervals used in affective intonation and therefore no comparisons between the two can be made.

When considering the melody line of a song even when excluding the variable of language, the melody is the combined result of pitch and rhythm added together. Music cannot be reduced to the individual musical elements and studied for their effects on mood as music contains combinations of elements. Music is far more complex than such simplifications. Nonetheless, studying mood in music is complex and, not surprisingly, there has been a drought in further development of the understanding of this phenomenon.

A recent study by Schellenberg, Krysciak, & Campbell (2000) examined the interactive effects of pitch and rhythm in the perception of mood in melody. Results showed that pitch strongly contributed to the perceived mood in melody whereas rhythm had a much weaker influence. Nevertheless, when rhythm had an effect, the interaction with pitch was necessary to evoke the intended mood state. The same finding stands for prosody whereby the intonation (use of pitch) plays a more important role in differentiating mood states than does rhythm and tempo (Bolinger, 1986).

There has been much debate on whether music increases or decreases arousal. From this grew the concepts of *stimulative* and *sedative* music, both of which have been discussed extensively in the music therapy and music psychology literature. Stimulative music has been said to activate people and is often employed when an increase or maintenance of activity is required. Conversely, sedative music promotes relaxation responses. It was mentioned earlier that there is a high incidence of feelings of anxiety among people with TBI. Some literature suggests that sedative music has the potential to reduce anxiety and facilitate a change to a state of relaxation (Davis & Thaut, 1989; Robb, 2000; Robb et al., 1995; Stratton & Zalanowski, 1984; Strauser, 1997; Thaut and Davis, 1993).

In evoking a sedative state, Robb et al. (1995) propose that slow to moderate tempos are best combined with a rhythm that is regular, smooth, flowing and without

sudden changes. They advocate that melodies that are slow, sustained and progress by step are the most desirable in addition to a melody of low pitch register (they believe that high pitched notes increase tension). Finally they suggest that the dynamics of the music should remain in the soft to moderately loud range. Interestingly, these are the same characteristics typical of lullabies, which are used for their qualities to promote sleep in infants (Trehub & Trainor, 1998). Given that the music characteristics of Robb et al.'s description evoke relaxation responses, adopting music that falls within these criteria would seem appropriate for people with TBI who present as tense and anxious.

While researchers have shown that sedative and stimulative music may evoke or modify moods suggestive of relaxation or elation respectively, several authors have examined the importance of the subjects' relationship of the music as a factor influencing the direction and degree of mood response (Davis & Thaut, 1989; Kerr et al., 2001; Thaut & Davis, 1993; Wheeler, 1985).

Davis & Thaut (1989) found that subject-selected music facilitated decreases in state anxiety and increased levels of self-reported relaxation responses. Different styles of music were effective in bringing about a positive change, probably the result of preference and familiarity with the music and/or some association with past experiences. The importance of subject-selected music was further explored by Thaut & Davis (1993). Differences in state anxiety and self-perceived levels of relaxation following subject-selected music and experimenter-selected music (sedative music as established by previous studies) were evaluated. Results indicated that both subject-selected and experimenter-selected music facilitated a decrease in anxiety and increased relaxation. This finding might suggest that the effect of familiarity with the music (regardless of music style) may equate to the effects of sedative music. There was no description of whether any of the subject-selected music comprised of components described as being sedative.

Wheeler (1985) also found that subject-familiarity with the music influenced the degree of mood responses. She added that the pre-existing moods of the listeners influenced their mood responses. People initially displaying a depressed mood, became less depressed after hearing music they liked, but remained depressed when they listened to music they did not like. In contrast, people who were initially happy became sad when they listened to music they did not like but remained happy when listening to music that they did like. This finding certainly advocates the necessity to use subject-preferred music when mood elevation is a key goal of therapy.

In support of this idea, Aldridge (1996) discussed how attempting to match the mood of music via analysis of its components neglects people's individuality in response to music. He argues that mood response to music cannot be generalized. He states that:

“The same piece of music can soothe one listener yet irritate another in its crassness and superficiality. One listener may delight in a dissonance, another may find it disturbing..... Furthermore, music may have a particular response at a certain time in a person's life, but later be heard quite differently” (Aldridge, 1996, p.153).

It is perhaps these concepts that support Wheeler's (1985), Davis & Thaut's (1989) and Thaut and Davis's (1993) findings about the effectiveness of subject-selected music selections. It remains to be answered whether subject-selected music will evoke stimulative or sedative responses in the listener. Further research is necessary to determine the relationship between the properties of the music and the relationship of the music to the listener.

Despite Aldridge's (1996) assertion that people respond in individual ways, he also alludes to the fact that some commonalities in responses do occur, and it is the challenge of researchers now to separate what could be common from that which is individual. This idea of a common mood response to music has been the subject of Leonard Meyer's (1956) text *Emotion and Meaning in Music*. This seminal text focuses on the idea that music evokes mood, based on the tension-resolution relationships in the music, and that these tension-resolution relationships arise from previous experience of music of the same style/culture. Of relevance to this study is the proposition that mood in intonation is also a culturally determined phenomenon primarily learned through repeated experience to the intonation within one's own culture.

Several conclusions can be drawn from this review concerning the effect of mood on emotion. First, not only can music evoke mood responses in people, it can also be used to either elevate or relax people's pre-existing mood states. Certain characteristics of music tend to evoke different mood states, and some of these features are also characteristic of affective intonation patterns, further supporting the existence of a relationship between emotional expression in music and in intonation. Several research projects indicate that subject-selected music facilitates a reduction in anxiety and tension to the same degree as experimenter-selected music when the musical characteristics of the experimenter-selected music align with those components said to evoke a sedative response.

Given the literature overview presented, it would seem that subject-selected music would be more appropriate for people with TBI (Baker, 1999; 2001a; 2001b). However, it is clear from the research that many aspects of why and which music arouses different mood responses are still unclear. The individual together with changes in his mood, context, and life experience mean that he will not experience the same mood response to the same piece of music each time it is heard. Therefore, mood responses to music cannot be predicted. With respect to the current study, a specified mood response to music was actually not the goal of the project and therefore, specific music was not chosen for evoking any specific mood response. It is hypothesised that some unspecified mood response will occur as a consequence of participating in the music and that this response will effect a change in intonation patterns.

### **3.9 Summary, problem statement and research questions**

The literature shows that intonation in speech plays a number of roles in a person's life including linguistic and affective communication, personal identity, and as an indicator of physiological and psychological health. Intonation is the result of complex processes originating in the brain and manifesting in the physical act of vocal fold movement. Some literature suggests that emotional and physiological functioning can positively or negatively influence the flexibility of the vocal folds. Negative influences would restrict vocal range and perhaps intonation range although the degree of restriction has yet to be determined.

Following TBI, it appears that injury to the LH, RH and/or basal ganglia can result in the total or partial loss of vocal fold control. When this affects intonation, the person may demonstrate reduced pitch range, monotonal speech, inappropriate  $F_0$  (too high or low for age and sex of person), and inappropriate changes in pitch. Documented treatment of these impairments is largely absent both within the speech pathology and music therapy literature. There is a necessity to develop programs to address this need given the impact it has on these people's lives and the increasing number of people who have sustained TBI. Descriptions of techniques by speech pathologists indicate that feedback strategies (auditory, visual, and verbal) and vocal exercises involving imitation, modelling and self-monitoring, all contribute to the enhancement of intonation function of these people. Music therapy clinicians have also described similar techniques within a musical framework.

Relaxation techniques recommended by speech pathologists and music therapists point to the shared belief that the voice is influenced by physiological tension, a factor said to exacerbate voice disorders. Song singing has been implicated as a useful tool in addressing the poor pitch control,  $F_0$ ,  $F_0$  range, and  $F_0$  variability of subjects participating in music therapy programs. The frequent citation of song singing in the speech pathology literature is further evidence of the shared belief that this tool is useful.

Improvement in intonation following the implementation of goal directed therapy might be explained by the concepts of plasticity whereby the stimulation of the brain through appropriately created experiences stimulates the brain's reorganisation and therefore recovery of function. This is not surprising given the similarities between the structure and function of music and speech and the neurological processes driving them. However, some music therapy clinicians argue that work on the emotions or mood of a person or the person's physical state, lead to enhanced vocal flexibility. To date, no study has investigated the influence of these two factors on the temporary or permanent improvement in vocal flexibility. Given the research of music's effect on the emotions and its implied effect on the physiological functioning of the body, and given that the vocal apparatus is so strongly linked with affective states and physiological tension, it seems logical to predict that these two factors may also affect the immediate level of functioning and long term potential for recovery in clients with disorders of intonation. It follows that certain mood states and/or levels of physiological states could potentially accelerate improvements made to vocal intonation. This possibility has yet to be verified by research.

Another question relates to what impact improved singing pitch range and accuracy in pitch control has on people with TBI who present with impairments in intonation. The literature and clinical experiences reported here point to the idea that music therapy would improve these skills and have a corresponding immediate and long term effect on improved affective intonation in people with TBI.

The primary research question addressed in this study relate specifically to affective intonation, and people's ability to express different emotions following their participation in music therapy.

**Research Question:** Does song singing improve the affective intonation of people with traumatic brain injury?

More specifically, the following sub-questions were constructed for this study:

q.1 In what ways do affective intonation contours ( $F_o$ , variability and slope) change in people with TBI?

q.2a. Does a song-singing intervention facilitate changes in vocal range?

q.2b. Does a song-singing intervention facilitate changes in mood?

q.2c. Does a song-singing intervention facilitate changes in pitch control?

q.3a. Do changes in intonation correlate with changes in vocal range?

q.3b. Do changes in intonation correlate with changes in mood?

q.3c. Do changes in intonation correlate with changes in pitch control?

q.4. Are people with TBI more expressive in communicating a range of mood states following a song singing program?

Throughout the following text, the research sub-questions will be referred to by number. Chapter 4 describes the method used to answer these questions.

## **CHAPTER 4**

### **RESEARCH METHOD**

#### **4.1 Facility**

This study was conducted at Ivanhoe Private Rehabilitation Hospital in Victoria, Australia, a facility providing inpatient and outpatient rehabilitation services for people with TBI. Inpatient length of stay can range from three weeks to 18 months. Factors that influence the length of stay include the severity of brain injury, the age of the client, and the geographical location of the client's family. The rehabilitation services provided by the hospital comprise general medicine, nursing, neuropsychology, occupational therapy, physiotherapy, speech pathology, social work and music therapy. A transdisciplinary approach to treatment is in operation within the hospital with client and family being active members in deciding the focus of treatment.

#### **4.2 Research Design**

A multiple case study design was selected and comprised of four individual cases. This design was assessed as the most appropriate for several reasons. First, it allowed for the inclusion of several sources of data to investigate the phenomenon (Yin, 1994). Second, because of the inherent difficulties involved in recruiting matched subjects for inclusion in experimental designs (Sholberg & Mateer, 1989), case study was considered more practicable. Third, the case study design accommodated for the fact that some variables could not be controlled (for example: medication side effects, psychosocial issues)(Yin, 1994). Furthermore, the pool of subjects available was small and therefore studying these phenomena in an experimental design was not achievable in the timeframe set for the project.

The multiple case study design was also selected because it allowed for direct comparison between the different cases; for possible identification of common response patterns; and for exploration of the variations and differences in responses between the different cases. The case study design was of an exploratory nature as it was unclear whether a clear single set of responses would emerge (Yin, 1994).



### 4.3 Recruiting subjects

#### 4.3.1 Inclusion criteria

In order to select subjects for the study, 13 selection criteria were developed. Gender, educational level and religious background were not thought to influence results, and so were not taken into account during the selection process.

*Criterion 1:* The subject had received a TBI, this being the specific pathology under investigation. Subjects with either diffuse or localised brain damage were eligible to participate, as both these injuries are typical of subjects presenting with the condition under investigation (Baken, 1987; Fortune & Wen, 1999). Admission as an inpatient to Ivanhoe Private Rehabilitation Hospital automatically indicated that the subject had received a TBI and therefore met this criterion.

*Criterion 2:* The subject was at least 18 years of age. Subjects younger than 18 were ineligible for the following reasons:

- a. the visual analog mood scale, the mood scale adopted in this study, had not been tested with people younger than 18 years of age (Stern, 1997);
- b. the vocal characteristics of people under 18 may not have stabilised following the structural changes in the larynx that occur during puberty (Aronson, 1990; Hargrove and McGarr, 1994). It was necessary to exclude subjects where changes to pitch control might be explained by normal development and not necessarily an outcome from treatment.

*Criterion 3:* The subject was 65 years of age or younger. Subjects older than 65 years were ineligible for the following reasons:

- a. prognosis for recovery is not as high as that of younger people (Prigatano, 1999b) and therefore subjects older than 65 would be less likely to demonstrate the full potential of the effects of the treatment program under investigation;
- b. they are not typically representative of the people who receive TBI (Fortune & Wen, 1999) and therefore not representative of the population under investigation.

*Criterion 4:* The subject had not emerged from posttraumatic amnesia (PTA) more than 12 months prior to the commencement of the study. This was to ensure that the subjects were in a period where potential for improvement was high (Nudo, Barbay, & Kleim, 2000), this being the period within 12 months of PTA resolution.

*Criterion 5:* The speech pathology screening test (SDT) (Appendix 10.4) indicated that the subject displayed impairments in the use of voice during normal conversational speech. A disturbance was defined if the subject's vocal presentation was assessed as falling into one or more of the following categories:

- a. moderate to severe disturbance in intonation (question 8b);
- b. minor disturbance in intonation (question 8b) plus a moderate to severe disturbance in vocal pitch register (question 1);
- c. minor disturbance in intonation (question 8b) plus a moderate to severe disturbance in vocal pitch control (question 2).

*Criterion 6:* The subject demonstrated normal or minimal impairment in initiating and articulating verbal communication. Impairments in verbal articulation and speech initiation may result in some subjects diverting their attention away from focusing on the intonation impairment and instead focusing on the accurate articulation of words. This may limit the subjects' possibilities for maximum therapeutic benefits, which were directed towards improving pitch control and intonation. Furthermore, by excluding subjects who had difficulties articulating or initiating verbal communication, the sample of subjects selected were more likely to present with disturbances to pitch control and intonation as the primary disturbance to communication production.

*Criterion 7:* The subject had no difficulty sustaining phonation as evidenced by obtaining a score of at least three in question 6 of the SDT (indicating that phonation can be controlled at a moderate to excellent level) and sustaining phonation for least three seconds (as tested in question 7). Subjects meeting these criteria are likely to be able to articulate short phrases in a single breath.

*Criterion 8:* The subject was able to read simple sentences. Some tasks in the pre- and post-session assessment tasks required the subjects to read simple sentences. Simple sentences were those that were short, concrete and contained simple vocabulary (words used in daily conversations). This approximated the reading level of the sentences used in the intonation tasks of the pre- and post-session assessments (4.5.2).

*Criterion 9:* The subject had no known history of a language delay/disorder or voice disorder prior to receiving the TBI. This controlled for the possibility that the voice disorder was not a consequence of the neurological damage but some other factor.

*Criterion 10:* The subject spoke Australian English as a first language. This was included to ensure that only people with similar pre-trauma intonation patterns were being compared with the non-clinical sample.<sup>15</sup>

*Criterion 11:* The subject's next of kin had completed the consent form.

*Criterion 12:* The subject was assessed as being able to attend the music therapy treatment two to three times per week for five to eight weeks. Note that if the subject was to be transferred to a different hospital where he would be absent from inpatient care for a week or longer, then the subject was not eligible to participate in the study. If the subject was scheduled to be discharged as an inpatient of the hospital during the five to eight weeks but available to return as an outpatient, then he was eligible to participate in the study.

*Criterion 13:* The subject fulfilled the following criteria as assessed in the pre-selection tests (4.3.3).

- a. The subject had minimal or no difficulty in auditory discrimination tasks, scoring correctly on  $\geq 70\%$  of items (a score of at least seven out of ten). This criterion was included to establish whether the subject's difficulty in pitch control was only expressive in nature and not compounded by a deficit in receptive discrimination (sensory amusia: Wilson & Pressing, 1999).
- b. The subject was comfortable singing in the presence of the music therapist and in using the research equipment (particularly the microphone headset). It was necessary to ascertain that participating in the research was not going to be a stressful and unpleasant experience for the subject.
- c. The subject had not demonstrated the existence of vocal amusia as indicated by his ability to sing the melodic contour of a familiar song with and/or without lyrics. Rationale for this criterion was that during the music therapy program, subjects needed to utilise some degree of musical skill. Note that the subject was asked to sing the familiar song with and without the lyrics. This aimed to assess whether there were differences between verbal and non-verbal access routes to melodies stored in the brain (Besson, Faita, Peretz, Bonnel, & Requin, 1998; Bonnel, Faita, Peretz, & Besson, 2001; Peretz et al., 1994).<sup>16</sup> For eligibility to

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<sup>15</sup> Significant differences in mean  $F_0$  were found between people of different ethnic backgrounds (Andrianopoulos, Darrow, & Chen, 2001).

<sup>16</sup> There is an absence of a standardised test for assessing automatic recall of melody that is or is not triggered by lyrics (Wilson & Pressing, 1999).

participate in the study, the subject's performance needed to fall into at least one of these two categories:

1. able to follow the melodic contour of the song without using lyrics with only medium, mild or no difficulty;<sup>17</sup>
2. able to follow the melodic contour of song with lyrics with only medium, mild or no difficulty.

#### **4.3.2 Screening of subjects**

In order to assess the presence of impairments in intonation, pitch control and pitch register, the speech pathology department screened potential subjects using the Speech and Diagnostic Test (Subtelny, 1975 cited Darrow & Gfeller, 1996, p.240-241). In addition, the speech pathologists assessed and collected data on the subjects' ability to articulate language clearly, level of reading ability, pre-trauma language ability, and native language. Where suitable, the speech pathologists referred subjects to the music therapy clinician for further assessment of eligibility.

#### ***Speech and diagnostic test***

The Speech and Diagnostic Test (SDT) was originally designed for use with hearing-impaired people (cited Darrow & Gfeller, 1996, p.240-241). It was used here to determine whether the subject met criteria 5, 6, 7 and 8. As the speech of hearing impaired people contains many similarities with the speech of people with TBI, this assessment was considered appropriate for the screening of subjects.<sup>18</sup>

To complete the SDT, the speech pathologist rated the subject's abilities and impairments in the following areas: pitch register and pitch control, loudness and loudness control, speech rate, control of air expenditure and breath control, prosodic features (blending and stress, and intonation), voice quality (breathy, weak, lacking clarity, tense, harsh), nasal resonance, and pharyngeal resonance. Only pitch register, pitch control, and intonation were under investigation in the study, and only the results pertaining to these three aspects of the test are reported.

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<sup>17</sup> Medium difficulty indicates that the subject can follow the overall contour of the song and sing some intervals with accuracy; mild difficulty indicates that the subject only produces occasional errors in accuracy of pitch change.

<sup>18</sup> Similarities include monotonal voice, intonation impairments, and inappropriate fundamental frequency (Darrow & Gfeller, 1996).

The SDT is a test based on the speech pathologist's subjective assessment of the subject's voice production. Previous research has established that subjective tests that rely on clinicians' perceptions are generally subject to inaccuracies and are therefore unreliable in measuring change (Hargrove & McGarr, 1994). Furthermore, Darrow & Gfeller (1996) provide no information about the reliability or validity of this scale. Nevertheless, the purpose of this test was not to provide accurate measurements of subjects' vocal characteristics but rather to screen subjects for suitability and eligibility to participate in the research project. Furthermore, tests specifically designed to assess emotional expressivity such as Cancelliere & Kertesz's (1990) Battery for Emotional Expression and Comprehension, and Ross, Thompson, & Yenkosky's (1997) Aprosody Battery, are time consuming because they include completion and assessment in detail a range of aspects to prosody, not just intonation. Such details were not required for the present study and therefore the simpler and shorter SDT was deemed appropriate.

The treating speech pathologists employed at the facility were provided with copies of the SDT (Appendix 10.4) and were instructed to complete this test for any subjects aged between 18 and 65 who they considered demonstrated a significant voice disturbance as a consequence of the TBI. The instructions for the test were clearly stated on the front sheet of the test (Appendix 10.4). At the same time that this test was carried out, the treating speech pathologist checked the medical file to gather relevant information such as pre-trauma language abilities and whether the subject spoke Australian English pre-trauma.

Each subject's report was forwarded to the treating music therapist for further assessment. If the subject met criteria one to ten, then the subject was eligible to participate in the pre-selection tests.

#### **4.3.3 Pre-selection tasks**

The pre-selection tasks were conducted with each subject to determine whether the subject met criteria 13 a, b, and c. In addition, the pre-selection tests included an intonation discrimination task to ascertain how well the subject was able to discriminate between different emotions as portrayed through the voices of two speakers. This was included to ascertain whether poor expression of emotion was due to impairments in the subject's perception of emotion or was purely impairment in expression.

The music therapist invited the subject to participate in the research pre-selection tests. At that time, she also informed the subjects that there was no obligation to participate in the research and that participation in the pre-selection tests did not automatically

indicate that the subject was eligible to participate in the full study. The music therapist also emphasised that the subject was able to receive the music therapy services irrespective of whether consent was given to participate in the research project. If the potential subject consented to participate in the pre-selection tests, then the music therapist and subject arranged a time for the testing session.

At the scheduled testing time, the subject was led into the music therapy treatment room and asked to be seated in the chair provided (subjects in wheelchairs were wheeled into the room and positioned accordingly).

The subject was informed that he would participate in three exercises, which comprised activities of singing, listening and writing. The descriptions of each task follow.

### ***Pitch discrimination task***

At the time this project was designed, the researcher was not able to access pitch discrimination tests designed for the normal population or for people with TBI. Therefore, this task was generated specifically for this study. The task required the subject to determine whether the second tone of two sounded tones (herein termed interval) was higher or lower in pitch than the first tone. The two tones were recordings of piano notes, which were sounded for a second each with one second of silence inserted between them. A period of five seconds of silence was then inserted before the same interval was played again. This exercise was repeated with a total of 11 different sets of intervals. The first of these 11 intervals was a sample item completed for the subject to illustrate how the exercise was to be completed. Eight seconds of silence was inserted between each of the 11 items.

The intervals were pre-recorded on mini-disc, and these audio recordings were then transferred to computer and edited using Cool Edit 2000™ (4.9.4) according to the specifications previously documented. Finally, the audio data were burned onto a compact disc. The track was labelled *pre-selection test: pitch discrimination task*, for playback.

The subject was given a pen and a form to note down his answers to each item (Appendix 10.5). Note that the information presented on the form was printed in Times New Roman font size 18 to ensure that the subject was able to read the information (to control for any potential visual impairments). The subject was then informed that the first exercise was a listening exercise and the music therapist commenced the compact disc recording and played the sample item. Following this, the music therapist paused the

recording and asked the subject if he was clear about what he was expected to do. If the subject agreed that he was clear, the music therapist recommenced the compact-disc recording and left it playing until the task was completed. The duration of the task was 3 minutes 33 seconds. The specific protocols provided to the music therapist are detailed in Appendix 10.6. The instructions provided to the subject were as follows:

Please listen to the piano sounds recorded on the CD. You will hear two notes. They will be separated by a pause and then played again. You are asked to decide whether the second note is higher in pitch or lower in pitch than the first note. After you hear the two notes, mark a cross in the correct box on the form. You will see on the form that this exercise is repeated ten times. Please listen to the first example, which has been completed for you.

Eleven items were included (ten excluding the sample) for the following reasons:

- a. the task was kept short to ensure subject concentration and interest remained high throughout the task and to limit the possibility of fatigue;
- b. a task of less than ten items may be insufficient to assess the subject's ability and may be unreliable, chance having a greater influence on the reliability of the results.

The intervals selected were no greater than an octave and the majority of intervals were less than a major 6<sup>th</sup> (Appendix 10.7). The second tone was either higher or lower in pitch than the first tone. There were approximately equal numbers of higher and lower second tones included in the 11 items. As the subjects were more likely to correctly discriminate between tones of larger intervals, these were placed at the beginning of the task so that the subjects could be clear about the requirements of the task, and to provide opportunities for subjects to experience feelings of success. The intervals were played on pitches in the middle range of the piano ( $G^2$  to  $G^4$  or 98Hz to 415.3Hz), this range being characteristic of conversational speech and therefore suitably matched to the intonation discrimination task described on page 89 (Colton and Casper, 1996).

Answers to this task were scored by assigning a score of one for correct responses and zero for incorrect responses. If the subject had answered at least seven of the ten items correctly, then he had satisfied criteria 13a.

### ***Singing of a familiar song***

A task comprising the singing of a familiar song was included to assess whether the subject was able to sing comfortably in the presence of the music therapy clinician and

with the microphone headset, and to assess whether the subject had a clinical presentation of vocal amusia.

The music therapy clinician first placed the microphone headset on the subject (as per instructions, 4.9.1) and commenced recording of the mini-disc recorder. The music therapy clinician then asked the subject whether he knew the song *Happy Birthday*. If the subject agreed that he knew the song, then this song would be the material utilised in this task.<sup>19</sup> The music therapy clinician then directed the subject to sing the song *Happy Birthday* without the lyrics, singing it to the vowel sound *ah*.<sup>20</sup> The song was sung solo by the subject and accompanied on guitar by the music therapy clinician. The music therapy clinician did not sing along with the subject. Although it was thought that the subject's performance might be enhanced by the harmonic accompaniment (thereby not providing an accurate picture of the subject's ability), the subject might not have felt comfortable to sing without an accompaniment. Given that the songs used in the study were accompanied by guitar, it was considered appropriate to include it in the pre-selection tests. The accompaniment was chordal with a deliberate avoidance of a melody to control for the possibility that the guitar may have triggered the singing of the melody.

Following this, the music therapist directed the subject to sing the same song with lyrics. If the subject had difficulty remembering the words, the music therapist provided a copy of the lyrics. This was considered acceptable to the study, as during the music therapy intervention, the subject would be permitted to use copies of the lyrics if required. Again and for the aforementioned reasons, the subject's singing of the lyrics was accompanied by a chordal accompaniment with a deliberate avoidance of playing the melody. The specific protocol provided to the music therapist has been included in Appendix 10.8.

As this task was for screening purposes only, subjective assessment by the music therapist was regarded as sufficient to determine the subject's ability to produce the melody with and without lyrics. The following criteria were used:

- a. unable to follow the melodic contour;
- b. severe difficulty following the melodic contour;
- c. medium difficulty following the melodic contour;
- d. mild difficulty following the melodic contour;

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<sup>19</sup> If the subject stated that he did not know the song *Happy Birthday*, then the treating music therapist suggested *Jingle Bells* as an alternative. It was assumed that at least one of these two songs would be known to most Australian people (Wilson & Pressing, 1999).

<sup>20</sup> The vowel sound *ah* has been adopted in many studies on voice (Ingrisano, Perry, & Jepson, 1998; Morris & Brown, 1996; Sihro & Sala, 1996; Teles-Magalhaes, Pegoraro-Krook, & Pegoraro, 2000).



- e. no difficulty following the melodic contour.

Eligibility to participate was based on the subject displaying medium, mild or no difficulty in following the melodic contour (c, d, or e).

### ***Intonation discrimination task***

The pre-selection tests included an intonation discrimination task aimed to measure the subject's ability to discriminate different emotions contained in speech samples. In this task, emotionally charged intonation was embedded into emotionally neutral sentences, this being modelled on the design of Tompkins (1991). The use of nonsense sentences as described in Appendix 10.2 was not used as it was considered inappropriate for this clinical population due to the probable existence of associated cognitive impairments. As the specific content of Tompkins' test was not described, the material used in the following test was formulated specifically for this study.

Eleven sentences were constructed for this task based on the following criteria:

- a. sentences contained emotionally neutral words.
- b. all sentences were capable of being intoned with all four emotions depending on the preceding context (happy, sad, angry, and afraid). These *basic* emotions were chosen as they are the most common emotions evaluated in intonation studies (Davitz & Davitz, 1959; Fairbanks & Pronovost, 1939; Murray & Arnott, 1993; Pittman 1994; Tompkins 1991)
- c. sentences were unlikely to reflect the subjects' feelings or thoughts. This was to eliminate the possibility of an incorrect response. For example the sentence *Are we nearly home yet?* could be intoned to portray the emotions of angry, sad or happy, depending on context. However, the subject might incorrectly identify the mood portrayed by the speaker based on the subject's own possible feelings or desire to go home.
- d. sentences were not longer than six syllables as outlined by Tompkins (1991) to ensure that the information provided for emotion identification was limited. The more information provided to the subject, the easier it would be for the subject to identify the expressed emotion, and the more unreliable the assessment of this skill.

The number of syllables per item ranged from three to six syllables ( $M = 4.5$  syllables per sentence) (Appendix 10.9). Each spoken sentence was less than three seconds in duration.

The constructed items were spoken and recorded onto mini-disc by two Australian people – one male (aged 31) and one female (aged 31). Both male and female voices were included for balance. The recordings were transferred to computer where they were duplicated and ordered according to the list described in Appendix 10.9 using Cool Edit 2000™ (4.9.4). Two identical hearings of each sentence were prepared with five seconds of silence inserted between them. Four seconds of silence was inserted between each item. The audio data were then burnt onto a compact disc for playback, with the track labelled as *pre-selection: intonation discrimination task*. The duration of the tasks was approximately 3 minutes and 30 seconds.

Eleven items were included (ten excluding the sample) for the following reasons:

- a. it was an equal number to that used in the pitch discrimination task and therefore simpler for direct comparison;
- b. the task was kept short to prevent the subject from losing interest in the activity and consequently not concentrate as well during the final items of the task;
- c. a task that was less than ten items may be insufficient to determine the subject's ability and may be unreliable, chance having a greater influence on the reliability of the results.

This task was piloted with students from The University of Queensland, who were asked to identify the emotion portrayed in each of the ten sentences. Results indicated that students were able to identify the correct emotion for a mean of 8.6 of the sentences ( $n = 23$ ,  $SD = 0.78$ ).

At the commencement of the task, the music therapist informed the subject that the task required him to identify the emotion portrayed by the speaker. The researcher read the following instructions slowly and clearly:

You will hear 11 sentences read to you by two different people (some are spoken by a male and some by a female). Each of the sentences is spoken in a way that suggests a mood. For example, the person speaking may want to tell you he is happy through the way she speaks. Please listen carefully to the people speaking and circle the mood that best represents how you think the person is feeling when he speaks. Each item will be repeated. There will be only four moods to choose from: happy, sad, afraid and angry. Note that some of the sentences have been repeated in the test, but spoken with a different emotion and spoken by a different person. Please listen to item one on the CD. The correct answer to item one has been completed on the answer sheet as a sample for how to complete this task.

The subject was provided with a form printed in Times New Roman size 18 font, to record his answers (Appendix 10.10). The music therapist then commenced the playing of the compact disc, which began with the sample item. Following this, the compact disc was paused and the music therapist asked the subject if he was clear about what he was expected to do. If the subject agreed that he understood the task, the music therapist recommenced the playing of the compact disc and left it playing until the task was completed. Appendix 10.11 describes the protocol provided to the music therapy clinician.

The music therapist tallied the number of correct responses and recorded the score directly on the subject's response sheet. A correct answer was assigned a score of one and an incorrect answer was assigned a score of zero.

#### **4.3.4 Obtaining consent**

Once it was established that all criteria for inclusion were met, the subject's next of kin was provided with a detailed leaflet describing the project (Appendix 10.12). At this point, the music therapist briefly explained the research project and asked the next of kin to sign the consent form attached (Appendix 10.13). If consent was given, the subject was admitted to the project.

#### **4.3.5 Family questionnaire**

The next of kin was asked to complete a questionnaire, which was attached to the information package (Appendix 10.14). This questionnaire, comprising of four questions and designed specifically for this research project, asked the next of kin to describe his/her perceptions of the subject's voice from pre to post injury. It sought to ascertain whether there were changes in the subject's voice production post-trauma, and to what degree these changes existed. For example, it was possible that the subject's pre-trauma voice was typically monotonal in quality. Therefore, the potential degree of change in the subject's voice following treatment would not be expected to be as large as might be the case for other subjects whose families had reported a more substantial change in vocal characteristics.

The family was asked to complete and then return the completed questionnaire to the music therapy clinician.

#### 4.3.6 Musical background questionnaire

Prior to the commencement of the music therapy intervention, the subject was asked to complete a questionnaire, which comprised questions about the subject's musical background (Appendix 10.15). This questionnaire requested information about:

- a. how important the subject considers music
- b. whether he had ever played an instrument; which instrument was played; and for how many years it was played
- c. how much music he would have listened to on average, each week

Determining the musicality or the level of importance that music played in these subjects' lives was considered important when the cross-case analysis was conducted, as it was considered that the subjects with greater musical experience/musicality may respond differently (O'Callaghan, 1999).

The questionnaire also sought information about the subject's involvement in singing-based music activities to ascertain to what degree singing had been a part of the subject's prior experiences and how potentially well-developed the control of the subject's voice was prior to injury.

Finally, the subject was asked to list songs and/or bands that he particularly enjoyed listening to/playing along with/singing to. This was included to derive a list of songs that could be drawn from when the music therapist came to selecting song material for inclusion in the treatment program. Note that some of these questions were taken directly from a questionnaire that the researcher devised in a prior research study (Baker, 1999).

#### 4.3.7 Subject descriptions

The following section describes the characteristics of the four subjects who met the inclusion criteria and were subsequently admitted to and completed the study. Table 13 below outlines the subjects' age, their Glasgow Coma Scale scores (GCS) on admission to the trauma centre, their length of posttraumatic amnesia (PTA length) in months, the time in months between PTA resolution and commencement of participation into the study (time of admission) and the neurological injuries reported on admission to the trauma centre.<sup>21</sup> Note that the neurological injuries reported in the medical files were not comprehensive. All available data were included in Table 13.

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<sup>21</sup> There was no subject A in this study. A female client from the facility where the research was conducted was coded subject A. She was included in this study to trial the assessment tools used. None of her data were collected and analysed. To avoid confusion and possible human error, the first subject eligible for participation in the study was coded subject B.

**Table 13. Subject background information**

| <i>Subject</i>   | <i>Age</i>     | <i>GCS</i> | <i>PTA<br/>length</i> | <i>Time of<br/>admission</i> | <i>Neurological injuries</i>   |
|------------------|----------------|------------|-----------------------|------------------------------|--|
| <b><i>B</i></b>  | 29             | 3/12       | 5                     | 4                            | diffuse axonal injury; haemorrhages in intracerebral, frontal (including subarachnoid region), ventricular haemorrhages, petechial (bifrontal and interhemispheric regions), brainstem; midbrain and brainstem contusions            |
| <b><i>C*</i></b> | 26             | 3/12       | 7                     | 9.5                          | severe haemorrhage to right frontal and left posterior parietal lobes; a small haemorrhage to right anterior of brain stem   |
| <b><i>D</i></b>  | 27             | 3/12       | 2                     | 7                            | diffuse axonal injury; bilateral frontal haemorrhage   |
| <b><i>E*</i></b> | 24             | 5/12       | 3                     | 2.5                          | severe acquired brain injury; extensive fronto- cortical contusions with haemorrhagic fluid cavity in the subcortical white matter; left frontal sheer injury; minor haemorrhagic sheer injury in right posterior of corpus callosum |
| Mean<br>(SD)     | 26.5<br>(2.08) | 3.5<br>(1) | 4.25<br>(2.21)        | 5.75<br>(3.12)               |  |

\* It was reported that subjects C and E had a significant impairment in cognition.

It can be seen in this table that subject C presented with the longest PTA duration and duration of time between PTA resolution and admission to the research. In addition, all four subjects received damage to the frontal lobe(s). There were large differences between subjects in the amount of detail reported concerning neurological injuries. Further, there were large differences in lesion sites reported between the four subjects.

Results of the speech pathologists' screening tests indicated that all four subjects displayed impairments in intonation and were therefore eligible for participation in the study. The results of this screening test are presented in Table 14. Table 14 also presents the families' perspectives to changes in the subjects' voices post-injury. This was calculated by subtracting each subject's pre-injury level of expressivity as reported by

family members on a 100mm line Likert scale from the family's reports of the subject's post-injury level of expressivity and then converting these scores to percentages.

**Table 14. Results of speech pathologists' screening tests and family questionnaire**

| <i>Subject</i>  | <b>Speech Pathologist Assessment</b> |                      |                   |                         | <b>Family assessment</b> |                              |
|-----------------|--------------------------------------|----------------------|-------------------|-------------------------|--------------------------|------------------------------|
|                 | <i>Pitch register</i>                | <i>Pitch control</i> | <i>Intonation</i> | <i>Phonation length</i> | <i>Pitch register</i>    | <i>Intonation</i>            |
| <b><i>B</i></b> | Slightly below optimum               | Flat                 | Moderate problem  | 8.9 sec                 | Higher than pre-injury   | 65% decrease in expressivity |
| <b><i>C</i></b> | Slightly below optimum               | Flat                 | Severe problem    | 5 sec                   | Lower than pre-injury    | No change                    |
| <b><i>D</i></b> | Moderately below optimum             | Flat                 | Moderate problem  | 6.3 sec                 | Lower than pre-injury    | 59% decrease in expressivity |
| <b><i>E</i></b> | Moderately below optimum             | Flat                 | Moderate problem  | 12.3 sec                | Lower than pre-injury    | 62% decrease in expressivity |

Table 14 shows families of three of the four subjects reported large decreases in their family members' ability to express emotion in their voice. It was reported by subject C's family that there was no change post-trauma. It was unclear as to how they came to this conclusion because the impairment was severe and would be noticeable even to an untrained professional. Subject B's family reported that his post-injury voice was higher in pitch register compared with the pre-injury vocal characteristics. Conversely, the families of subjects C, D, and E reported that the subjects' voices were lower in pitch post-injury.

Results from the speech pathologists' screening tests indicated that none of the subjects displayed impairments in speech articulation or had a pre-trauma communication delay. All subjects were reported to speak Australian English.

Results of the pre-selection tests are listed in Table 15.

**Table 15. Results from pre-selection tasks**

| <i>Subject</i> | <i>Pitch Discrimination</i> | <i>Intonation Discrimination</i> | <i>Happy Birthday No Lyrics</i> | <i>Happy Birthday With Lyrics</i> |
|----------------|-----------------------------|----------------------------------|---------------------------------|-----------------------------------|
| <i>B</i>       | 10/10                       | 6/10                             | Mild difficulty                 | Mild difficulty                   |
| <i>C</i>       | 8/10                        | 2/10                             | Mild difficulty                 | Mild difficulty                   |
| <i>D</i>       | 7/10                        | 10/10                            | Mild difficulty                 | Mild difficulty                   |
| <i>E</i>       | 6/10                        | 4/10                             | Mild difficulty                 | Mild difficulty                   |

It can be seen from this table that subject C had significant difficulty in discriminating emotion portrayed in the intonation of various speakers, scoring a total of two out of ten items correctly. All subjects had little to no difficulty in discriminating higher from lower pitches. The reports from the treating music therapist indicate that subjects were more tuneful in their singing of the melody line of *Happy Birthday* when the lyrics were present than when they were not.

The musical background for each subject is detailed in Table 16.

**Table 16. Musical background of the subjects**

| <i>Subject</i> | <i>Music listening<sup>#</sup></i> | <i>Song 1</i>   | <i>Song 2</i>                                  | <i>Song 3</i>  |
|----------------|------------------------------------|---|--|--|
| <i>B</i>       | 5+ hours                           | I heard it through the grapevine – Creedence Clearwater Revival | Under the bridge – Red Hot Chilli Peppers      | Comfortably numb – Pink Floyd                          |
| <i>C</i>       | 2 hours                            | Heavy Heart – You Am I  | You're the Voice – John Farnham                | Waltzing Matilda – Traditional                         |
| <i>D</i>       | 5+ hours                           | Layla - Eric Clapton  | Bad Moon Rising – Creedance Clearwater Revival | Sunday, Bloody Sunday – U2                             |
| <i>E</i>       | 5+ hours                           | Better Man – Pearl Jam  | Cecilia – Simon and Garfunkel                  | Knocking on Heaven's Door – Guns n' Roses <sup>*</sup> |

<sup>#</sup> Approximate number of hours of music listened to each week.

<sup>\*</sup> This song was originally performed by Bob Dylan.

Only subject B reported having prior musical experience, stating that he had played the saxophone for six years.

#### **4.4 Session design**

Each subject received 15 individual sessions of music therapy, two to three times per week, held over a five to eight week period. This design was selected as prior research indicated that short and intense (frequent sessions) programs facilitated significant improvements (Cohen, 1992; Darrow & Cohen, 1991; Darrow & Starmer, 1986). Sessions were between 40 to 50 minutes in duration (including the completion of data collection pre- and post-session). This duration was considered appropriate based on the research findings that sessions between 20 and 50 minutes (including warm up exercises) facilitate improvements in prosodic production (Cohen, 1992; Cohen, 1995; Cohen & Masse, 1993; Lucia, 1987).

Individual treatment was selected over group treatment to enable subjects' preferred songs to form the basis of their treatment. Group sessions require music selections suitable for all group members. As musical tastes vary, there was a low probability that subjects within the group setting would present with the same song preferences. In addition, it would not have been possible to capture subjects' voices with a clean audio signal had they been participating within a group setting. A clean audio signal was required for accurate analysis of subject responses to treatment.

The music therapist (not the researcher) who was employed by the facility conducted the music therapy sessions and the pre and post-session assessments for each of the four subjects. This person was an experienced music therapy clinician and had been working full time in this facility for three years.

#### **4.5 Pre- and post-session assessments**

The researcher chose to assess the subjects' musical and vocal intonation abilities prior to and following each session as a means of controlling for natural recovery. As subjects were still in the active phase of recovery, spontaneous recovery may have occurred over the course of the 15 sessions (Almli & Finger, 1992; Kolb, Cioe, & Whishaw, 2000; Nudo et al., 2000; Bach-Y-Rita, 2000). However, it was unlikely that positive changes from pre- to post-session were due solely to spontaneous recovery but more likely to be a combination of spontaneous recovery and treatment effects.



The pre- and post-session assessments comprised of four tasks and were administered by the music therapy clinician employed to conduct the program and collect the data:

- a. Singing pitch range
- b. Expression in intonation
- c. Melodic pitch matching exercise
- d. Visual analog mood scale

#### **4.5.1 Singing pitch range**

The subject's vocal pitch range was assessed pre- and post-session to identify whether there was a change in the subject's vocal range over the course of a single session and over time. Two tasks commonly used to elicit maximum vocal range are the use of glissando and the use of phonating in discrete steps. Both of these tasks have been evaluated as effective in obtaining subjects' maximum potential vocal range with high positive correlation and no statistically significant differences found between them (0.84) (Zraick, Nelson, Montague, & Monoson, 2000). The latter task was employed in this study because the directions were considered clearer and therefore understandable to people with TBI who may have difficulties in understanding complex instructions.

The music therapist placed the microphone headset on the subject as per instructions (4.9.1) and commenced the recording on the mini-disc recorder. The subject was then asked to sing the lowest pitch that he was able to without cueing by the music therapist (spontaneous participation). The music therapist then played a note on the piano that was one semitone lower than the note that the subject had just produced and asked the subject to try to sing that note. This procedure was repeated until the subject could no longer produce any lower notes. To establish the upper range of the subject's voice, the music therapist asked the subject to sing the highest note that he could without cueing. Following this, the music therapist played on the piano, a note that was one semitone higher than the previous note produced by the subject. This procedure was repeated until the subject could no longer produce any note pitches that were higher in pitch.

#### **4.5.2 Expression in intonation**

The  $F_0$ , standardised variability score (variability in pitch expressed in semitones), and the slope (change of pitch with time expressed in semitones) in a speaking task were assessed pre- and post-session in order to determine whether the subject was able to utilise

intonation to express a range of emotions. The task described below was designed specifically for this study, as there were no pre-existing tasks designed for this purpose at the time this research project was designed and implemented.

### ***Task description and design***

At pre- and post-session, the subject was asked to read aloud four different sentences, each expressing one mood. These sentences were printed on paper with Times New Roman font, size 18 with double spacing. Font size 18 was chosen to accommodate for possible post-trauma visual impairments. The subject's own reading of the sentence was preferred to the subject's imitation of the music therapist's production of these sentences. Each of the four sentences used in the pre-session assessment contained a keyword, which signified a mood (happy, sad, afraid or angry). With the exception of the keyword, each sentence was identical.

sentence 1. I feel *happy* today.

sentence 2. I feel *sad* today.

sentence 3. I feel *angry* today.

sentence 4. I feel *afraid* today.

This design was chosen so that the subject's production of each sentence could be more easily compared. If the sentences were not similar, comparison would be unreliable, as other factors, such as differences in length and rhythm of the sentence and accents placed on different syllables, may influence the subject's performance. By keeping the sentences identical, differing only by the insertion of a single word, the effects of these factors were minimised. With the exception of the sentence containing the word *sad*, the sentences contained six syllables, which were considered appropriate for completion in a single breath. Longer sentences may require more than one breath and possibly distort the flow of the intonation contour.

Sentences containing a predetermined emotion (identified by the keyword) were more likely to facilitate a greater use of intonation range, particularly the emotions of happiness, anger and fear, than sentences containing no emotional content (Apple et al., 1979; Mozzioconacci & Hermes, 1997; Murray & Arnott, 1993; Scherer, 1991). Ideally, the task should assess spontaneous conversation; however, there was a risk that in adopting this approach, the subject would not initiate sufficient spontaneous verbal material for analysis.

The four moods – happy, sad, angry and afraid – were chosen as they represented the four *basic emotions*, that is, not culturally specific but innate in the human species (Murray & Arnott, 1993). Second, the intonation characteristics of speech for these emotions have been studied extensively and therefore the results of the current study could be compared with previous research. In addition, these same moods were being assessed in the visual analog mood scale (4.5.4).

At the pre- and post-sessions, the subject was asked to say each of the four sentences expressing the mood described by the keyword for each sentence. The order of these sentences was randomised for each session to control for the possibility of a learned effect. The order of sentences for each session is listed in Table 17.

**Table 17. Order of sentences used in pre- and post-session tasks**

| <i>Sessions 1,6,11</i> | <i>Sessions 2,7,12</i> | <i>Sessions 3,8,13</i> | <i>Sessions 4,9,14</i> | <i>Sessions 5,10,15</i> |
|------------------------|------------------------|------------------------|------------------------|-------------------------|
| Happy                  | Afraid                 | Sad                    | Angry                  | Happy                   |
| Sad                    | Angry                  | Afraid                 | Happy                  | Angry                   |
| Angry                  | Sad                    | Happy                  | Afraid                 | Sad                     |
| Afraid                 | Happy                  | Angry                  | Sad                    | Afraid                  |

### ***Procedure***

The music therapist: informed the subject that he would be asked to say four sentences; placed the microphone headset on the subject; and commenced recording on the mini-disc. The music therapist then provided the subject with the first sentence *I feel happy today* printed on a piece of paper in Time New Roman, font size 18. The subject was then provided with the instructions:

“Try to imagine yourself feeling really happy and say this sentence as if you really feel like it.”

The same procedure was adopted for the remaining three sentences, inserting the new keyword for each sentence. This entire procedure was repeated for all of the 15 sessions.

#### **4.5.3 Pitch matching exercise**

Prior to and following each session, the subject participated in a pitch-matching exercise (PME). The subject was asked to first listen to and then sing intervals that were played on a compact disc. This was used to assess whether subjects could reproduce given intervals without the possible automatic recall typical of singing popular songs and without linguistic involvement. It also aimed to determine whether the subjects improved their control of pitch production independent of, or simultaneous with improvements in intonation.

##### ***Task description and design***

The two tones of each interval were recordings of piano notes which were sounded for a second each with one second of silence between the two tones. Two seconds of silence was then inserted before the same two tones were played again. The two piano notes were pre-recorded on mini-disc in the same way as prepared in the pitch discrimination task (4.3.3). This exercise was repeated to create ten items. These recordings were then transferred to computer, ordered according to design using Cool Edit 2000™ (Appendix 10.16) and finally the audio data were burned onto a compact disc for playback. Five seconds of silence was inserted between each of the ten items. The duration of the task was approximately 2 minutes and 30 seconds.

The task comprised of ten items for the following reasons:

- a. Longer tasks may cause fatigue or cause the subject to lose interest in the task, both of these factors potentially influencing the subject's performance.
- b. Tasks less than ten items may be insufficient to assess the subject's ability to pitch match and the results may be unreliable, chance having a greater influence on the reliability of the results.

The intervals selected were typical of those used in normal conversation (Fairbanks & Provonost, 1939) that is, intervals no greater than an octave. Although it was acknowledged that speech utilises a greater pitch range than an octave, an octave was considered appropriate for the subjects in this study given the likelihood of them displaying a reduced vocal range, this being common in people with TBI. Therefore it was not regarded as necessary to assess the control of pitch outside this range. Interval

directions were both rising and falling again as conversational speech includes both rising and falling intervals (Fairbanks & Provonost, 1939).

Two versions of the task (varying in the pitch register used) were prepared – a female and male version - to accommodate for gender differences in vocal range. There were no females eligible to participate in this study and therefore the female version of the task was never used. The order of interval presentation was randomised for each session to control for the possibility of the learned effect (Appendix 10.16).

### ***Procedure***

The music therapist placed the microphone headset on the subject and checked that the mini-disc recorder was recording. The subject was then provided with the following instructions, which were read slowly and clearly:

“When the CD begins to play, you will hear a piano play two notes. After two seconds of silence, the same two notes will be heard again. After you hear them the second time, please sing the two notes you have heard. There will be five seconds of silence and then you will hear two different notes. You should then wait until you hear them the second time and then follow the same procedure. There will be a total of ten sets of two-note piano sounds.”

#### **4.5.4 Visual analog mood scale**

During the pre- and post-session assessment, the subject completed the visual analog mood scale (Stern, 1997). This aimed to determine whether significant mood changes were evident as a consequence of participating in the treatment and whether these changes correlated with a change in intonation characteristics. Valid assessment of internal mood state is especially important in this population because mood states are often masked or mimicked by a variety of behaviours caused by neurological damage. For example in the cases of dysprosodia, pseudobulbar palsy, abulia, bradykinesia, the outward expression of mood (i.e. affect) may be incongruent with the internal emotional state (i.e. mood) (Stern, Arruda, Hooper, Wolfner, & Morey, 1997).

### ***Scale description***

The visual analog mood scale, herein VAMS, assesses subjects' mood according to eight mood descriptors: sad, afraid, energetic, happy, confused, angry, tired and tense. Each mood is represented by a face expressing the mood placed at one end of a vertical line (100mm long) with a neutral face placed at the opposite end (Appendix 10.17). The

person is required to mark along the line, the degree to which he is presently experiencing that feeling.

The scale allows for raw data to be analysed or the raw data to be transformed into *T*-Scores.<sup>22</sup> In this study, only the raw scores were analysed.

The VAMS was designed for repeated testing to determine a subjects' mood at any one point. However, moods are transient states and therefore, the VAMS test-retest reliability coefficients are somewhat lower than those typically found in measures of psychological traits. This leads to larger standard errors of measurement (mean standard error of measurement across all eight VAMS scales is approximately a score of five). A corresponding 95% confidence interval constructed around an obtained score is approximately equal to the score  $\pm 10$ . Therefore, pre-session and post-session scores that differ by more than 20 should be interpreted as reflecting a reliable change in level of mood and scores that differ by more than 30 should be interpreted as reflecting a reliable and clinically significant change in the level of mood.

### ***Test materials***

The VAMS response booklet is an integrated form that contains the test's instructions, a sample test item, and the eight individual visual analog mood scales (afraid, confused, sad, angry, energetic, tired, happy and tense). A copy of the response booklet has been included as an attachment (Appendix 10.17).

All VAMS scales are unipolar, containing a *neutral* schematic face (with the accompanying word *neutral*) at the top of a 100mm vertical line, and a specific *mood* face (and its corresponding verbal descriptor for example *angry*) at the bottom of the line. Each scale is printed separately on a single page in the response booklet. Scales are oriented *vertically* to avoid possible distortions or biases secondary to hemianopia or horizontal neglect. The faces are intended to ensure that subjects understood the scale when they had impaired or limited language skills. In case subjects had impaired visual-perceptual skills or difficulties discriminating among the subtleties of the different schematic emotional faces, verbal descriptors were printed above or below the neutral and mood faces, to aid their understanding of the scales.

***Rationale for selecting the VAMS***

The VAMS was selected to assess the mood of subjects for the following reasons.

- a. The VAMS is the only available scale specifically devised for people with neurological damage
- b. Most other available instruments for assessing mood are inappropriate for people with neurological impairments due to the length of these instruments and their reliance on intact cognition, language, attention, memory and emotional expression (Brumfitt & Sheeran, 1999; Lubin, Grimes, & Van Whitlock, 1997; Lubin, Van Whitlock, Dale, Riesenmy, & DeSouza, 1996).<sup>23</sup> VAMS was designed to allow clinical subjects who are unable to complete other verbally and cognitively demanding tests, the possibility of being assessed.
- c. Stern's (1997) scale utilises a 100mm vertical line, which acts as a unipolar scale rather than a bipolar scale. Here, the neutral pole is placed at one end of the line and an extreme endorsement of the emotion as described by the schematic face is placed at the opposite end. Stern (1997) stated that bipolar scales could result in ambiguous scores. For example, on a happy-sad bipolar scale, a score of 100 could be interpreted as either the lack of sadness or the extreme endorsement of happiness or mania.
- d. The VAMS was developed and standardised for the use in screening and assessment of mood for people aged from 18 years through to adulthood, matching the age of subjects in the present study.
- e. The VAMS was assessed as appropriate for use in clinical research trials where repeated assessment of mood states and measurement of treatment efficacy was desired (Stern, 1997).
- f. Subjects' self-reports of mood have been found to be more reliable than clinician reports (Möller & Von Zerssen, 1995; Stern et al., 1997; Stern & Bachman,

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<sup>22</sup> *T*-Scores are linear transformations of raw scores calculated to have a mean of 50 and a standard deviation of 10. These scores were based on testing different populations and establishing normative data. *T*-Scores are useful for judging the severity of pathological mood states relative to the general population (Stern, 1997).

<sup>23</sup> Subjects with impaired attention or with executive dysfunction (eg disinhibition, perseveration, poor abstraction) may provide inconsistent or unreliable answers to adjective checklist or similar test items. Subjects with memory impairments may not be able to complete the traditional mood scales because they are unable to recall their behaviour or emotional state from the days, or even the hours, prior to assessment. Finally, when interviewing a subject to assess mood, many subjects exhibit impairments of emotional expression (for example; dysprosodia, masked faces, pathological crying or laughing) that may inaccurately influence the interviewer's interpretation of the subject's internal mood state (Stern and Bachman, 1994).

- 1994). Clinicians can be biased and are liable to *halo effects*, forming a general impression rather than rating specific items in accordance with preconceptions based on it. (Möller & Von Zerssen, 1995). Note, however, that subject self-report is also subject to bias, as subjects tend to select socially acceptable responses rather than the true one. Although this is more apparent in personality questionnaires, there is some evidence that depressive symptoms are also considered socially undesirable (Möller & Von Zerssen, 1995) and subjects may intentionally manipulate their responses to present themselves in either a favourable or unfavourable light (Van Whitlock, Lubin, & George-Curran, 2000).
- g. The VAMS is quick to administer limiting the possibilities for randomised scoring as a result of a loss of concentration.
  - h. The VAMS can assess small changes to mood state.

### ***Test-retest reliability***

Because the VAMS are self-report scales with a simple scoring task of measuring the length of a line, interrater reliability is not relevant. However, test-retest reliability is frequently poor in self-report measures of depressive symptoms, due in large part, to the fluctuating nature of mood states (Stern, 1997). Very rapid changes in VAMS might be expected because mood can fluctuate quickly in people with neurological impairment. People with TBI can fatigue easily and emotional lability is common. Therefore, measures of test-retest reliability may be expected to be low, not because of measurement errors per se, but because of the instrument's sensitivity to small changes in mood (Stern, 1997).

Stern et al. (1997) studied the reliability of test-retest for two populations. First, they tested the scale with the normal population with test-retest reliability coefficients for each scale assessed as follows: sad = .49, afraid = .69, energetic = .72, happy = .73, confused = .67, angry = .73, tired = .76, tense = .78.<sup>24</sup> Second, they assessed stroke subjects with test-retest reliability coefficients somewhat higher (sad = .83, afraid = .84, energetic = .44, happy = .71, confused = .43, angry = .75, tired = .60).<sup>25</sup> Low reliability for confused and energetic scales may be due to some stroke subjects' actual fluctuations in energy and subjective confusion.

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<sup>24</sup> Seventy-five male and female undergraduate and graduate students completed the VAMS, followed by 15 minutes of intervening self-report tests, followed by a second VAMS administration with the eight scales presented in a different order to the first testing.

<sup>25</sup> Twenty-seven male and female acute stroke subjects followed the same procedure as for the normal population.



### ***Validity***

Stern et al. (1997) also assessed the content validity of the faces without verbal labels.<sup>26</sup> With the exception of the tense scale, all resulting correlations were statistically significant ( $p < .001$ ), indicating that when verbal information was not provided for each of the VAMS scales, the meaning of the faces was apparent. Correlation coefficients were as follows: sad = .81, afraid = .50, energetic = .77, happy = .90, confused = .48, angry = .71, tired = .42 and tense = .26.

Two separate studies of convergent and discriminant validity were conducted with samples from the normal population (Nyenhuis et al., 1996; Stern et al., 1997) and one with clinical subjects (Arruda, Stern & Legendre, 1997). The eight VAMS were compared with the Profile of Mood States (POMS) (McNair, Lorr & Droppleman, 1981, cited Stern, 1997, p. 47), the Becks Depression Inventory (Steer & Beck, 1985) and the State-Trait Inventory (Spielberger, Gorsuch, & Lushene, 1970, cited Stern, 1997, p. 47). Each of the VAMS had good to excellent validity and accounted for a substantial amount of variance in depressive mood states when compared with lengthier, more verbally demanding instruments. The details of the findings have been presented in Appendix 10.18.

### ***Sensitivity to treatment effects***

Arruda et al. (1997) assessed the construct validity of the VAMS when depressed subjects received electroconvulsive therapy (ECT). Prior to and following ECT treatment, the VAMS and Hamilton Depression Rating Scales (HDRS; Hamilton, 1960) were administered. With the exception of the confused scale, the VAMS scores exhibited significant improvement from pre-test to post-test. The HDRS and VAMS effects sizes were similar despite the fact that the VAMS is a brief scale. These results show that the VAMS were sensitive to treatment effects.

### ***Procedure***

Prior to and following each session, the VAMS booklet was given directly to the subject to complete. The directions were printed on the front page, which explained what the subject must do:

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<sup>26</sup> Ninety-six undergraduate and graduate students completed the no-word VAMS (that is, the faces were printed on the page with no verbal label attached), then completed approximately 15 minutes of other self-report tests and then completed the VAMS scale a second time, this time with the words labelling the pictures of faces.

On the following pages you will see eight sets of scales. On each of the scales you will see drawings of two faces connected by a long line. A “neutral” face will appear at the top of the line, and a face showing an emotion will appear at the bottom of the line. The name of the emotion that the face represents will be printed below the face. For each scale, place a mark across the line at the point which best describes HOW YOU ARE FEELING RIGHT NOW. If you wish to change an answer, scratch out or erase the incorrect mark and make a new mark. Be sure to make a mark and only one mark for each scale. Do not leave any scale blank unless the examiner tells you to do so.

The following text was taken from the sample item, also printed on the front page of the booklet, which aimed to help the subject understand what was required in his completion of the VAMS:

On the first scale, the more afraid you are feeling today, the closer you would make your mark toward the bottom of the line, as shown in figure 1 below. If you are not feeling afraid, you would make your mark toward the top of the line, as shown in figure 2 below. If you are feeling somewhere in-between, you would make your mark somewhere around the middle of the line, as shown in figure 3 below. These three figures are meant only as examples of how to use the scales. Your actual responses should be marked on the scale in the place that best relates to how afraid you feel. Please respond to all of the scales in this manner.

Under normal circumstances the VAMS should take no more than five minutes to complete. If the subjects had difficulty understanding the written directions, the music therapist was able to provide assistance or clarification. However, under no circumstance did the music therapist assist the subject to complete the test by interpreting the subject’s mood, and deciding where the exact response mark should be drawn.

## **4.6 Music therapy treatment**

### **4.6.1 Design of music therapy intervention**

Song singing was the intervention adopted in this study. The sessions were structured and tailored to meet the needs and musical interests of each subject. The music therapist’s primary aim was to encourage the subject to participate to his fullest potential, therefore she was free to use whatever therapeutic techniques she believed would obtain the best therapeutic outcome. Such techniques included the use of body language, gesture, or verbal encouragement.

The music therapist engaged the subject in active song-singing activities comprising three songs familiar to the subject. The same music selections were used for the 15 sessions to control for differences in responses related to choice of music material.

For example, the subject might have had a stronger connection or emotional response with some songs when compared with others. However, the order of songs presented in each session was not controlled as it was anticipated that this factor would not substantially influence the subject's performance. The subject was provided with the opportunity to select the order that the songs were sung during each session.

#### **4.6.2 Selected music material**

The three songs were selected by the music therapist from a list of preferred songs previously provided by the subject in the music background questionnaire. The decision to include preferred songs was based on the finding that subjects with brain injury respond well to preferred music (for example: Baker, 2000; Kennelly et al., 2001). Preferred songs engage subjects and motivate them to sing (Baker, 2000) and stimulate the automatic production of words and melody (Prior et al., 1990; Samson & Zatorre, 1992). This automatic response may result in the subjects using a greater pitch range than what can be achieved when they consciously attempt to produce a large pitch range (as in the pre- and post-assessment tasks). Finally, the repetition and predictability of melody, harmony, rhythm and form, typical of popular pre-composed music (the music most likely to be chosen by the subjects), provide structure to ensure that subjects are able to anticipate the direction of the melodic contours.

The music material was restricted to three songs in order to limit the length of the music therapy treatment program. Longer sessions may be cause fatigue, which may negatively influence the post-session assessment scores.

#### **4.6.3 Music therapy intervention procedure**

Following the completion of the pre-session assessment tasks, the music therapy intervention commenced. The music therapist recommenced recording the audio data on the mini-disc recorder. She then asked the subject to choose a song from the list of three preferred songs selected for the treatment program. Following the subject's choice of song, the music therapist provided the subject with a sheet containing the written song lyrics in case the subject had difficulty recalling the words. The music therapist then directed the subject to sing the song together with the music therapist.

The subject was then asked to select a second song and the aforementioned procedure was repeated. Finally, the third song was performed by again following the same

procedure. The duration of the song-singing intervention was approximately 15 minutes. This procedure was carried out for the 15 sessions.

#### **4.7 Post-treatment tasks**

Following the 15 sessions of treatment, the subject was asked to participate in two post-treatment assessment tasks. These tasks and their corresponding analysis procedures were identical to the pitch discrimination task and intonation discrimination task carried out in the pre-selection session (4.3.3). The post-treatment assessment aimed to ascertain whether the subject had improved in his ability to discriminate pitch and affective intonation over the course of treatment.

In addition, the subject was asked to complete a questionnaire related to his perceived change in vocal function post-treatment. The questions asked the subject to comment on whether he had perceived improvements in his ability to express emotion in his voice (Appendix 10.19). The researcher acknowledges that this questionnaire is subject to bias as the subject may intentionally manipulate his responses to present himself in either a favourable or unfavourable light. However, the researcher was interested in the subject's perception of his own vocal change, so this task was included.

#### **4.8 Non-clinical sample**

In order to establish whether the subjects included in the study presented with different intonation characteristics to the normal population, a sample of ten male students of comparative age attending music education classes at The School of Music, The University of Queensland were recruited to obtain audio samples of their voices. The males were asked to speak the same four sentences as the subjects in the study and the same instructions were given. The males who were at the time attending music education classes, were recruited by teachers from the School of Music, University of Queensland. Males who were vocal majors were excluded from the sample as it was anticipated that music training would influence their speaking intonation characteristics (Morris et al., 1995; and Brown et al., 1993). None of these males were known to the researcher. Recordings of their voices were captured in the same manner as subjects in the study.

## 4.9 Audio recording equipment

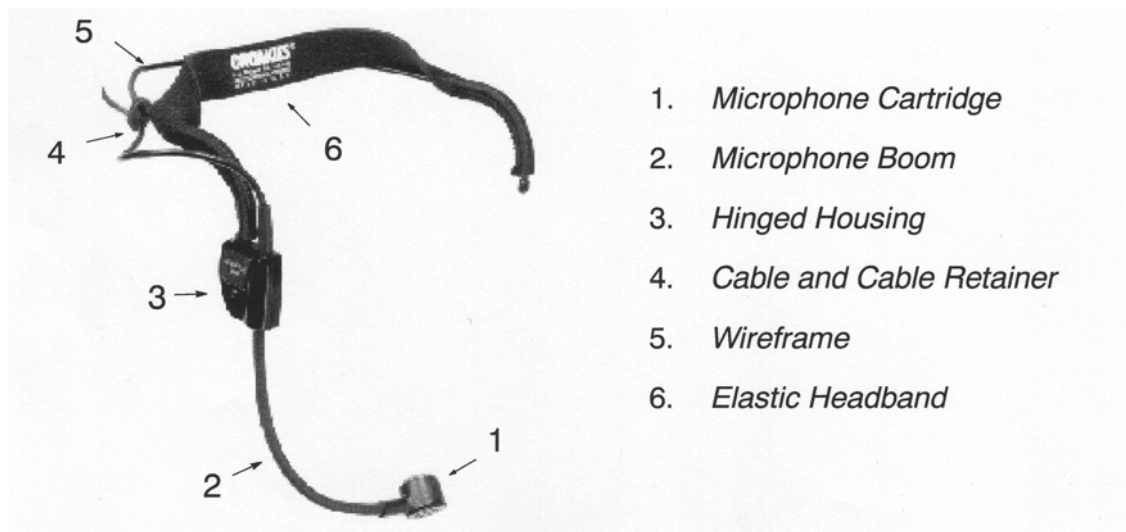
Equipment used to collect the audio data were:

- a. a Shure Microphone Headset Model WH20;
- b. a Sony mini-disc recorder model MZ R700;
- c. a Behringer mixer model MX602A;
- d. Cool Edit™ wave file editing software.

Descriptions of the equipment are detailed below.

### 4.9.1 Shure microphone headset - model WH20

The Shure microphone headset Model WH20 was selected as the most appropriate microphone to record the audio data. It is a uni-directional, rugged, lightweight, dynamic microphone headset that provides high-quality voice pickup, and is designed specifically for active microphone users, such as aerobics instructors and musicians (Figure 2).

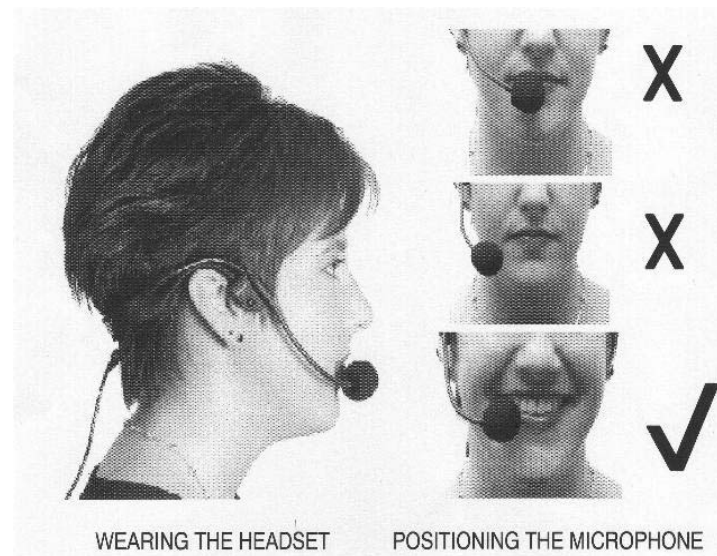


**Figure 2. Shure microphone model WH20**

Because the subject's voice was the target audio signal required for analysis, isolating the subject's voice from that of the music therapist and the accompanying instrument was essential. Utilising a uni-directional microphone headset minimises contamination of the audio signal from environmental noise. It was envisaged that the subject might move or turn his head away from the microphone unexpectedly if a standard microphone was used. The headset ensured that the subject's voice remained at a

consistent distance from the microphone, thereby ensuring a reliable and consistent audio signal was captured.

The headset was designed so that the wire frame and elastic band were horizontal across the back of the head and the ends of the wire frame fit over and in front of the ears. The correct positioning of the headset is shown in Figure 3.



**Figure 3. Position of microphone headset**

#### **4.9.2 Sony mini-disc recorder model MZ R700**

The Sony mini-disc recorder MZ R700 was used to record all audio samples involved in the project. Specifications include digital recording level control for consistent recordings, sampling frequency of 44.1kHz, frequency response of 20 – 20,000 Hz, and digital AGC (Automatic Gain Control) to prevent overload distortion.

#### **4.9.3 Behringer mixer model MX602A**

The Behringer mixer MX602A was used to adjust the recording decibel levels of the subject's voice to ensure that the audio signal being recorded was not distorting but was also of sufficient intensity to be analysed by the software program. The mono-input channels have the following specifications:

Bandwidth 10 Hz to 60 kHz,  $\pm 3$  dB

Distortion (THD and N) 0.007 % at +4 dBu, 1 kHz, Bandwidth 80 kHz

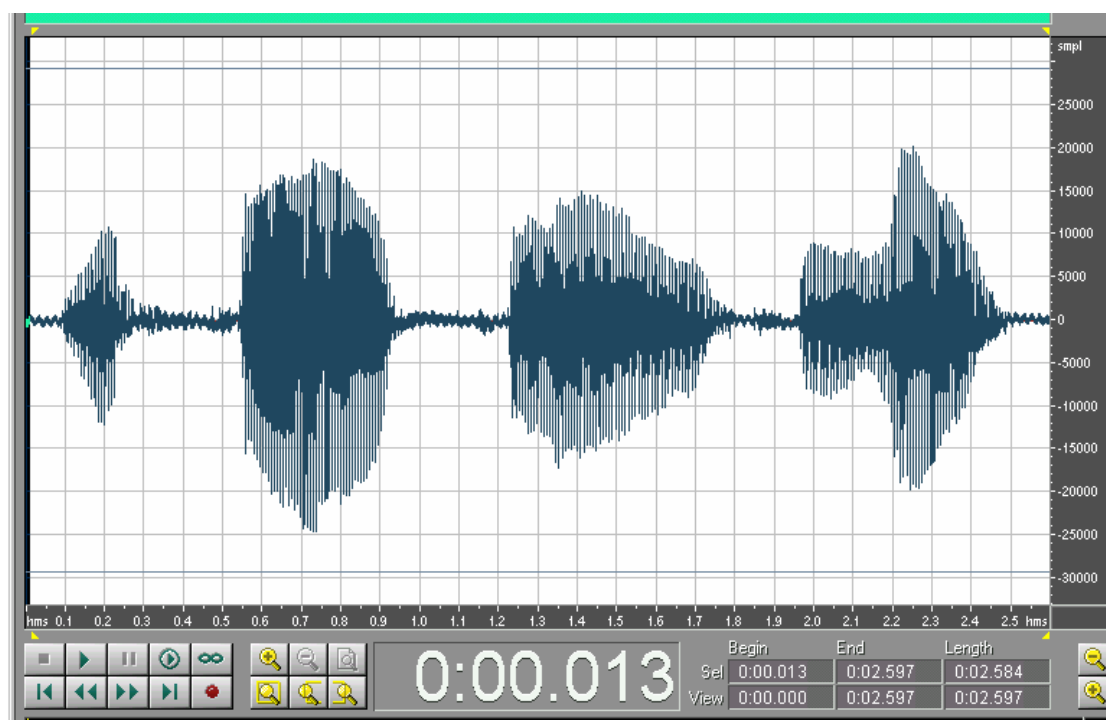
Gain range +10 dB to +60 dB

Signal-to-noise ratio 113,6 dB

#### 4.9.4 Cool Edit 2000™

Cool Edit 2000™ is a digital audio recorder, editor, and mixer. It allows the audio data from a mini-disc recording to be imported into a personal computer where the audio data can be cut, pasted, moved around and filed. Among other audio effects, the program can amplify the audio signal when its intensity is too low for analysis, and offer noise reduction functions.

This software program was used to prepare the audio material for the pre- and post-session tasks and the pre-selection and post-treatment tasks. Here, the recorded piano sounds and voices of the male and female were imported into the program. Sections of the audio were then cut, rearranged, pasted, and sections of silence inserted between sections of audio to prepare them for the various exercises. Cool Edit™ was also used to cut, paste and file the subjects' audio data collected during treatment sessions. Figure 4 provides an example of how the waveform is represented in the program.



**Figure 4. Sample of wave file in Cool Edit™ program**

From this display, relevant and important sections of the audio sample can be identified, isolated, cut, and pasted elsewhere or saved as a file.

#### 4.10 Multi-Speech™ model 3700

The software analysis program Multi-speech™ model 3700 with its Real Time Pitch 5121 module, is a windows-based speech analysis program that uses standard multimedia hardware to capture, analyse and play speech samples. The program includes displays for analysis, including wave form, spectrum, spectrogram, more than twenty voice parameters, pitch, palatogram, motor speech protocols and measurements, audio synchronisation, digital filtering and formant values. It was selected as the primary voice analysis tool for several reasons:

- a. perceptual (subjective) assessments of vocal contour have been found unreliable when utterances are rated by the same judge (poor intra-rater reliability) and between different judges (poor interrater reliability) (Kent, Vorperian, & Duffy, 1999);
- b. standardised perceptual measures were not designed specifically for assessments of treatment outcome but were designed for screening or diagnostic purposes only (Hargrave & McGarr, 1994);
- c. Normative, reliability and validity data for perceptual assessments are rare. Therefore, assessment of treatment effects may be unreliable or the effects are so subtle that the clinical judgements of clinicians may not discern when a subject has made progress (Hargrave & McGarr, 1994). Furthermore, changes in other perceptual aspects of prosody may influence the perception of pitch changes. For example, a stable frequency may be perceived by the assessor as rising in pitch in contexts where only the loudness is increasing (Hargrave & McGarr, 1994).

The superior version of Multi-Speech, the Computer Speech Laboratory (CSL), has been cited extensively in research projects (for example: Eftmer & Mellon, 2001; Kent et al., 1999; Rosen, Lombard, & Murray, 2000; Wuyts, De Bodt, & Marc, 2000). This program performs the same functions as Multi-Speech however uses its own specialised hardware to reduce the effect of computer noise on the audio sample.

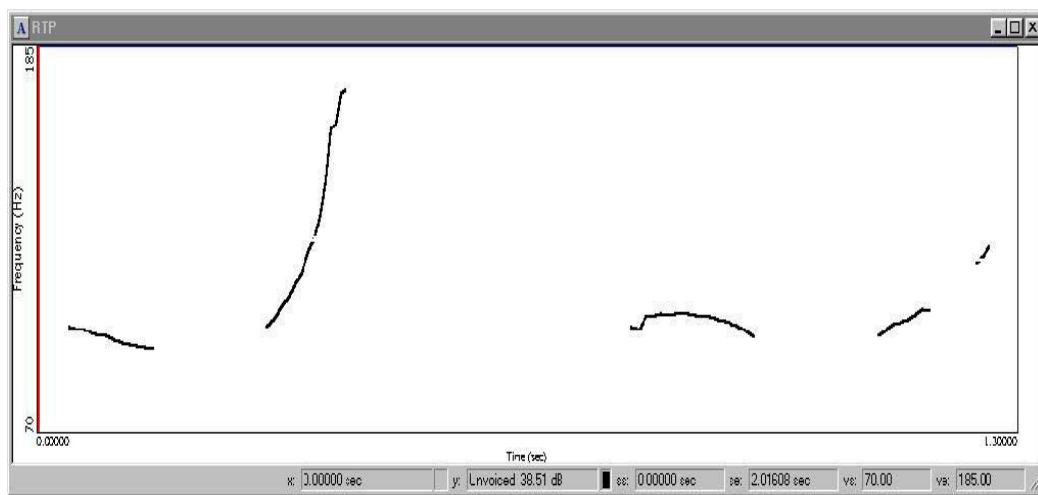
There were several reasons for selecting the Multi-Speech over the CSL:

- a. Multi-Speech is approximately one fifth of the cost of CSL, with the performance of Multi-Speech viewed as adequate for the project, particularly as Multi-Speech was used to assess changes in pitch over time rather than using the software as a diagnostic tool;



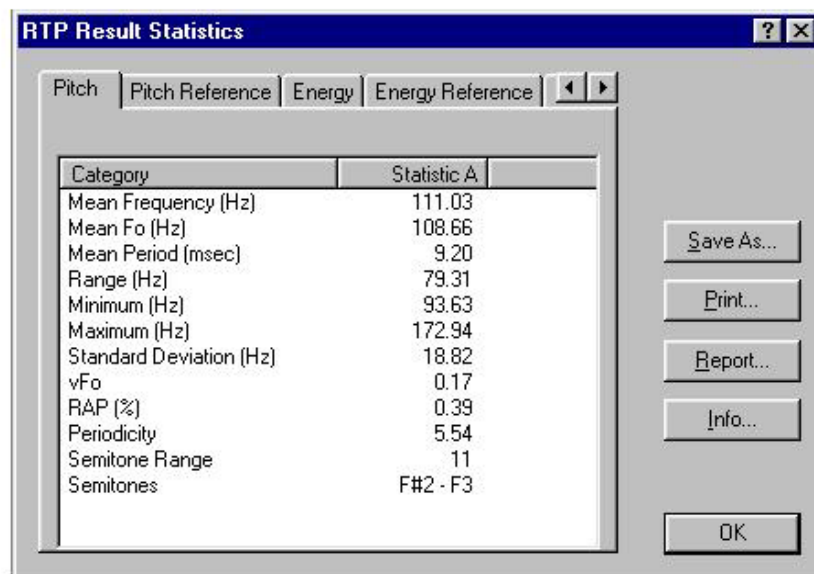
- b. Effective operation of the CSL requires extensive training and is difficult to use. Employment of CSL increases the risk of human error while recording the data. The mini-disc recorder, which was used to collect the data, is simpler and less likely to result in human error;
- c. the combined hardware and software program of CSL is physically heavy and not easily transported, while the mini-disc recorder is very portable;
- d. the CSL is a large instrument and looks like a piece of medical equipment in a hospital. This may have seemed invasive to the subjects, thereby jeopardising the safe and warm environment created by the music therapist. It was anticipated that this would have contraindications for the effects of treatment.

The Real-Time Pitch module model 5121, an option for both Multi-Speech and CSL, provides real-time pitch and energy displays of audio data in addition to the computation of numerical analyses. It extracts and graphically displays energy and pitch contours in real time. Stress, timing, and intonation patterns as well as pitch and amplitude values can be displayed graphically and numerically analysed. The program enables split screen analysis where a target utterance (that considered ideal by the clinician) can be compared with the utterance produced by the subject. Similarly, two separate utterances made by the subject can be compared. Figure 5 illustrates the frequency contour of an audio sample that has been graphically represented by the Real-Time Pitch module.



**Figure 5. Sample of contour plotted by the Real-time pitch module 5121**

Figure 6 shows a sample of the numerical data produced by the software analysis functions for the same audio sample.



**Figure 6. Sample of statistics generated by the Real-time pitch module 5121**

#### 4.10.1 Reliability of analysis

Kay Elemetrics' CSL product has been found reliable (Kent et al., 1999; Morris & Brown, 1996). Morris & Brown (1996) conducted a series of assessments examining the reliability of several voice analysis software systems for the variable of  $F_0$ . When the same sample of an utterance was repeatedly analysed by CSL (within system reliability), reliability was high ( $r = .86$ ) with a standard deviation of only 4.84Hz (less than a semitone). For sustained vowel sounds, the reliability was even higher with a standard deviation of under 1Hz ( $r = .99$ ). Of all the programs analysed, the CSL provided the most reliable and accurate average measure of  $F_0$ .

Ingrisano et al. (1998) state that there is an incorrect assumption that computer-based voice analysis systems are valid and reliable. In an article investigating the effect of environmental noise on computer-based voice analysis procedures, they listed the following threats to the accuracy of the signal analysis:

- voice signal type;
- length of analysis window and extraction procedures;
- instrumental arrays such as microphone type and distance to the mouth;

- d. recording method – direct-to-computer recording, digital tape recording or analogue recording.

In addition, environmental variables such as signal sound pressure levels and signal-to-noise ratios may affect the data analysis. Ingrisano et al. (1998) warn that poor signal-to-noise ratio conditions may result in the automatic analysis systems being unable to distinguish between the signal and extraneous noise, or the extraneous noise being interpreted as part of the voice signal, causing noise-induced errors. Their study assessed the impact of environmental noise on the accuracy of data analysis by using a Kay Elemetrics' product the Multi-Dimensional Voice Program™ 4305. The voice signal of a man was crossed with that of environmental noise (the sound of a computer fan) at varying decibel levels and then fed into the software program for analysis. Results indicated that estimates of vocal function were affected by environmental noise, with the higher signal-to-noise ratio producing the greatest inaccuracies. However, the  $F_0$ , one measure under investigation in the present study, was the least affected measure, varying only slightly across various signal-to-noise ratios. The estimated  $F_0$  of the man's voice, 126Hz, remained consistent across all signal-to-noise ratios, varying by less than 1Hz. More recently, Carson, Dennis, Ingrisano, & Eggleston (2003) reinvestigated various voice analysis software tools, also concluding that the  $F_0$  was the variable least affected by environmental noise.

#### 4.10.2 Statistical analysis functions of Multi-Speech™

The analysis functions performed by Multi-Speech that are relevant to this study were the mean  $F_0$  and the standard deviation.

The *mean  $F_0$*  reports the harmonic mean fundamental frequency. It is calculated using the formula  $M = n / (1/f_1 + 1/f_2 + \dots + 1/f_n)$ , where  $n$  was the total number of voiced periods and  $f_1 \dots f_n$  were the frequency values for each period. The software program also provides detail of every change in  $F_0$  with its corresponding time interval for the entire sample. For example Table 18 illustrates how the frequency of a portion of a syllable changes over time.

**Table 18. Sample of moment to moment changes in fundamental frequency**

| <i>Sample</i> | <i>Time (seconds)</i> | <i>Frequency (Hz)</i> |
|---------------|-----------------------|-----------------------|
| 1             | 0.00000               | Unvoiced              |
| 2             | 0.06510               | Unvoiced              |
| 3             | 0.06982               | 190.91                |
| 4             | 0.07506               | 163.33                |
| 5             | 0.08118               | 170.27                |
| 6             | 0.08705               | 177.82                |
| 7             | 0.09268               | 174.31                |
| 8             | 0.09841               | 172.27                |

The *standard deviation* measures the variability of the  $F_0$ . It reflects the spread of the data, or the average amount by which the data deviate from the mean. The standard deviation was computed in Hertz on all  $F_0$  values present in any audio sample analysed. High standard deviations are indicative of variability in the voice and low standard deviations reflect more monotonal vocal styles.

#### **4.10.3 Display and analysis options**

The on-screen display and analysis of pitch contour can be modified as required to a specified frequency range. These values can range from 0 Hz to 3000 Hz with a minimum separation of 10Hz. The pitch extraction algorithm can handle a large frequency range for most speech data. However, the disadvantage of allowing the analysis over such a wide frequency range is that some voiceless data in running speech may be processed as voiced and then assigned a pitch value. Narrowing the pitch analysis range can reduce the number of spurious pitch values being reported. Furthermore, limiting the frequency range reduces the effect of respiration of high frequency consonants such as *t* in *today*.

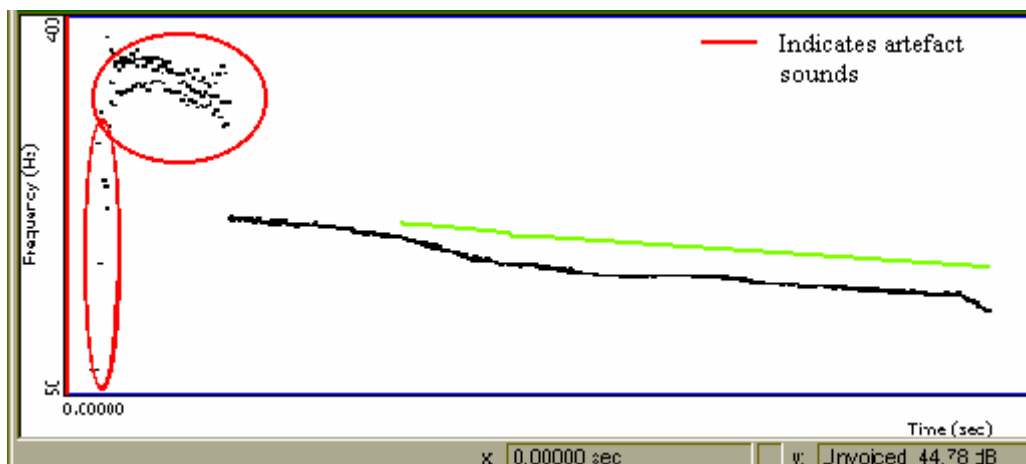
### **4.11 Preparation of audio data for analysis**

All the audio data were transferred from the mini-disc to a personal computer via a high quality sound card. The audio samples were then cut, coded and filed as individual wave files using Cool Edit 2000™ that could then be used for further analysis. However, before the final software analysis of the data could be calculated, data had to be trimmed

and the frequency range of the software set to obtain the most accurate measurement of the subjects' responses.

#### 4.11.1 Trimming data for analysis

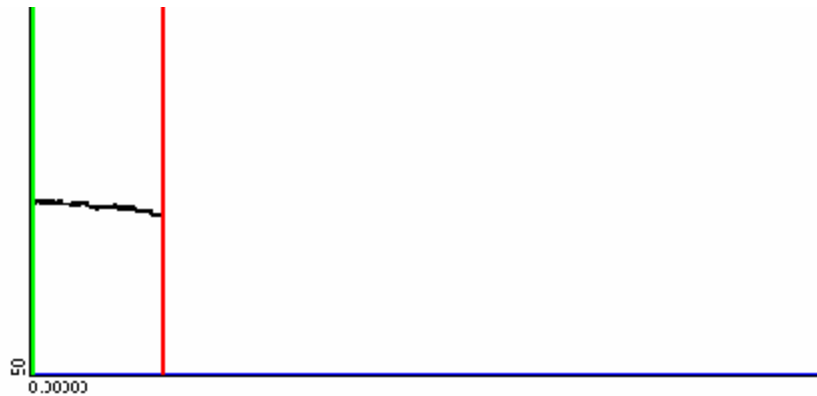
In the analysis of the PME and the vocal range audio samples, long sustained sounds were common. When these samples were uploaded into Multi-Speech, noise, hiss, and popping, present in the audio sample, often distorted the contour and therefore threatened the accuracy of the analysis. In these cases, the audio data had to be trimmed so that the subjects' best performance (indicating best potential) could be evaluated. In all cases, it was aimed that at least one second of audio material be available for analysis. In Figure 7, an example is given where the audio sample must be trimmed. The red markers indicate the presence of signal distortion or contamination and the green line illustrates how the frequency of the sustained vocal sound typically falls over time. It is necessary to select one second of audio that represents the subject's best performance.



**Figure 7. Example of audio signals requiring trimming**

Under normal circumstances, the first second of audio signal would be the most appropriate to analyse, given that the initial pitch produced is, in most cases, that intended by the speaker (Watts, Murphy, & Barnes-Burroughs, 2003). However, in the case illustrated in Figure 7, a portion of the first second of audio data is contaminated (circled in red) and should be isolated and discarded prior to analysis. Similarly, all portions of the signal following the first second of *non-contaminated data* should be isolated and discarded. When this trimming procedure was applied to the signal illustrated in Figure 7,

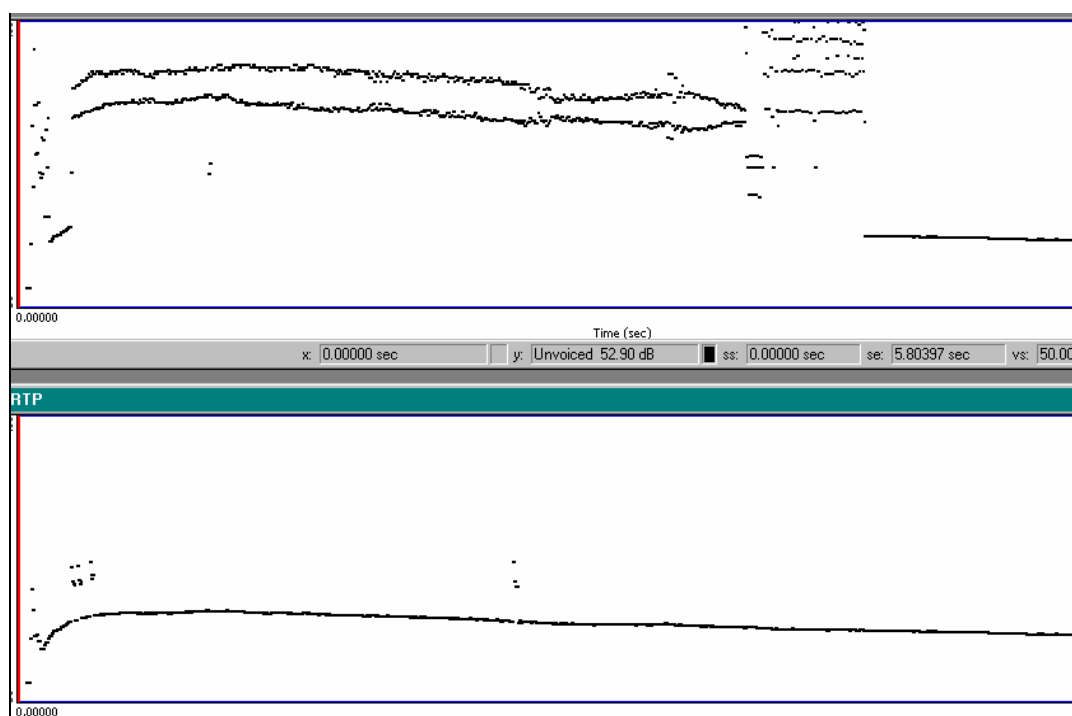
the remaining one second of audio signal as illustrated in Figure 8, is regarded as appropriate for analysis.



**Figure 8. Example of audio samples successfully trimmed**

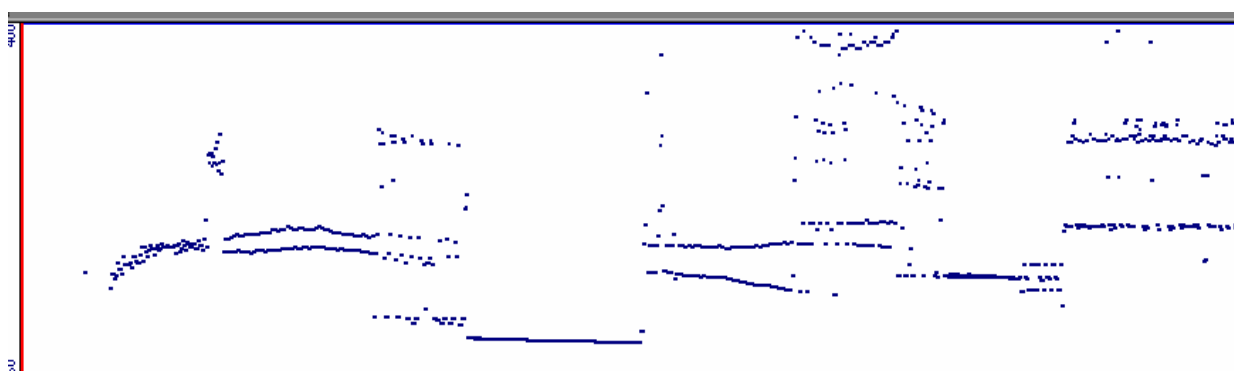
#### **4.11.2 Adjusting frequency processing range**

Even after carefully trimming the audio data, the accuracy of the software analysis was often disturbed by vocal noise and hissing present in the audio sample. In these situations, the frequency processing range was calibrated according to the typical vocal characteristics of each subject. In Figure 9, the frequency processing range in the first sample (upper graph) was set from 50 to 400Hz. It can be seen here that frequency overtones distort the analysis of the  $F_0$ , as illustrated by the break in the contour. In the second sample (lower graph), the frequency processing range for the same audio sample was set from 50 to 250Hz. The result of the second sample is a truer representation of the audio signal as illustrated by the continuous and unbroken vocal line. When attempting to limit the frequency range for audio samples in Figure 9, the researcher first evaluated the approximate vocal range of the subject based on previous analyses of the subject's recorded data. In the case of the subject from Figure 9, the maximum vocal range of the subject achieved to date was 220Hz. From this, an additional 30Hz was added to the maximum range in case the subject demonstrated substantial improvements during that particular session. This provided a rationale for limiting the maximum analysis range to 250Hz. This same procedure was followed whenever similar distortions in the melodic line were observed in the graphical displays of the vocal contours.



**Figure 9. Example of reducing frequency analysis range**

There were, however, occasions when the data could not be reliably analysed due to excessive contamination by hissing and extraneous noise. Figure 10 displays an example of highly contaminated data. In cases such as this, the data were discarded.

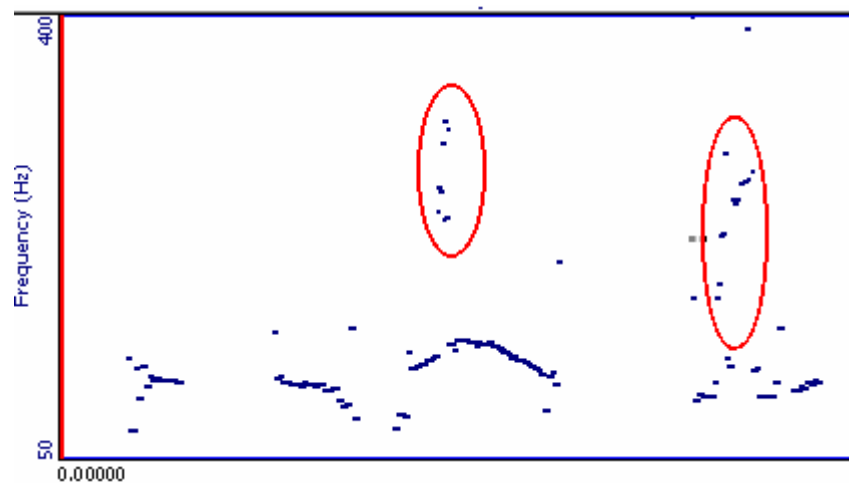


**Figure 10. Example of data unable to be analysed**

At the same time, it was not possible to trim the audio data for the sentence material and song phrases, given the necessity for them to be processed in their entirety. Therefore, another technique, pitch smoothing, was used to minimise the effect of artefact noise. Pitch smoothing, a post-processing function of the software, was performed to remove isolated

and outlying pitch values from the pitch contour, and then redraw the cleaned up contour. Statistical analysis of pitch that is subsequently performed would not include these de-voiced values. The post-processing routine consists of two steps. The first involves de-voicing voiced frames that are surrounded by voiceless frames. If less than three frames of voiced data are found, the voiced frames are made voiceless. The second component consists of de-voicing outlying pitch values that are different from the average value of the next five frames by more than 20%.

The next four figures illustrate how this procedure can change the statistics of the data and provide a more accurate analysis of what is heard perceptually. Figure 11 illustrates an audio sample of the sentence *I feel happy today*. Note that there are two large distortions in the contour, which represent the hissing sound of *h* in *happy* and *t* in *today* as indicated by the red circles.



**Figure 11. Sample of contour prior to adjustment to frequency levels**

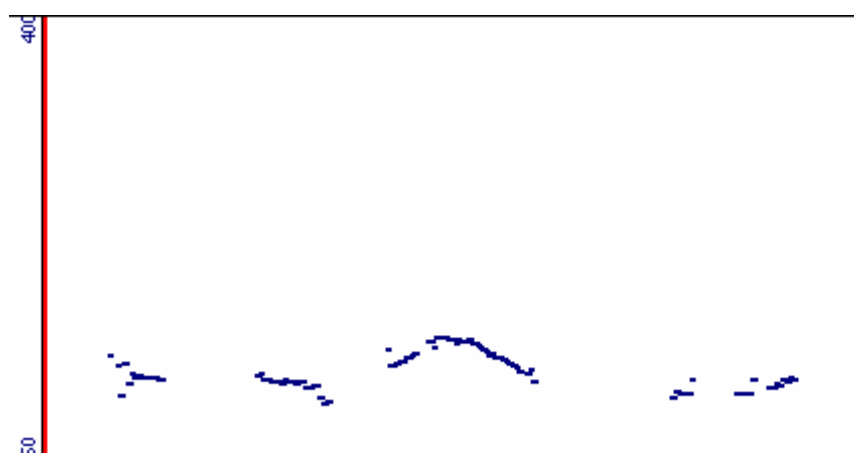
When this audio sample was analysed using the software program, the statistics shown in Figure 12 were reported. Notice that the semitone range was calculated to be 29 semitones wide, which when heard, was clearly an inaccurate calculation. In this case, the software was also calculating the  $F_0$  of the hissing sounds circled in red in Figure 11.



| RTP Result Statistics                             |             |  |
|---|-------------|--|
| Pitch Pitch Reference Energy Energy Reference ◀ ▶ |             |  |
| Category  | Statistic B |  |
| Mean Frequency (Hz)                               | 145.97      |  |
| Mean Fo (Hz)                                      | 129.87      |  |
| Mean Period (msec)                                | 7.70        |  |
| Range (Hz)  | 317.49      |  |
| Minimum (Hz)                                      | 72.77       |  |
| Maximum (Hz)                                      | 390.27      |  |
| Standard Deviation (Hz)                           | 60.21       |  |
| vFo   | 0.41        |  |
| RAP (%)   | 5.94        |  |
| Periodicity                                       | 1.10        |  |
| Semitone Range                                    | 29          |  |
| Semitones   | D2 - G4     |  |

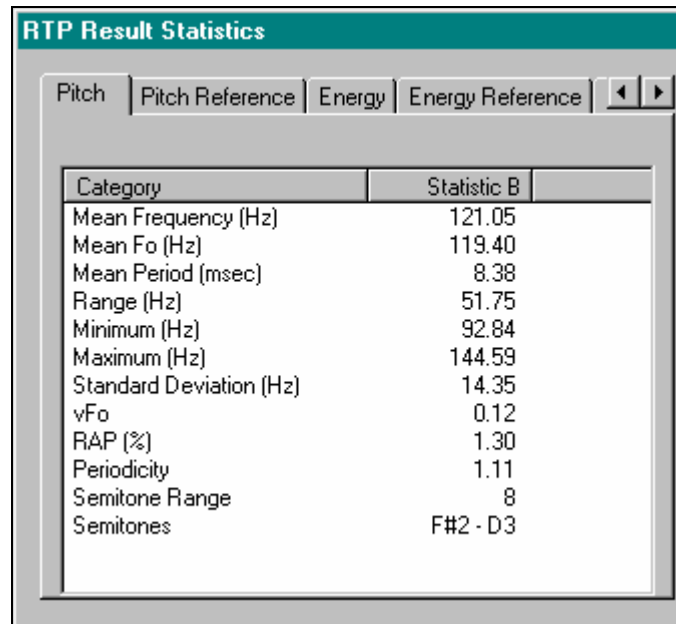
**Figure 12. Results of contour analysis pre-frequency adjustment**

When the same audio sample was processed through the pitch smoothing function, Figure 13 shows the new contour.



**Figure 13. Sample of contour post-frequency adjustment**

Figure 14 now reports the new statistics for this sample. Note that the semitone range has now been reduced to eight semitones, this being a more realistic and accurate assessment of the speech sample.



The screenshot shows a software window titled "RTP Result Statistics". It has four tabs: "Pitch", "Pitch Reference", "Energy", and "Energy Reference". The "Pitch" tab is selected. Below the tabs is a table with two columns: "Category" and "Statistic B".

| Category                | Statistic B |
|-------------------------|-------------|
| Mean Frequency (Hz)     | 121.05      |
| Mean Fo (Hz)            | 119.40      |
| Mean Period (msec)      | 8.38        |
| Range (Hz)              | 51.75       |
| Minimum (Hz)            | 92.84       |
| Maximum (Hz)            | 144.59      |
| Standard Deviation (Hz) | 14.35       |
| vFo                     | 0.12        |
| RAP (%)                 | 1.30        |
| Periodicity             | 1.11        |
| Semitone Range          | 8           |
| Semitones               | F#2 - D3    |

**Figure 14. Results of contour analysis post-frequency adjustment**

Once the audio sample had been prepared appropriately for analysis, each audio file was uploaded, analysed, and the results saved and filed accordingly.

## 4.12 Data analysis

The data analyses were divided into five parts.

1. Preparatory analysis;
2. Comparison of clinical and non-clinical samples;
3. Case study analysis;
4. Cross-case analysis of therapy outcomes;
5. Correlations between variables in cross-case analysis.

### 4.12.1 Preparatory analysis

#### *Pitch in spoken sentences:*

For each of the four sentences (happy, afraid, angry, sad) that were spoken by the subjects, the following pitch characteristics were used to measure treatment outcomes and developments over time.

- *Fundamental frequency* ( $F_0$ ) is the mean frequency of the sentence as described in 4.10.2. The software program calculated the  $F_0$ .
- *Standardized variability score* (SVS) is the standard deviation of the  $F_0$  within the audio sample, expressed in semitones. To calculate the SVS, the standard deviation of the  $F_0$ , which was given directly by the software program, was converted into semitones using a logarithmic transformation. The formula is given in Appendix 10.20. The SVS was preferred over the semitone range for the following reasons:
  - a. the SVS gives the typical rather than the maximum variation and was therefore expected to yield more meaningful results;
  - b. the SVS is less sensitive to artefact sounds such as popping or hissing noises than the semitone range and;
  - c. the SVS retains the full precision of the data, whereas the semitone range is rounded to whole semitones (integers).
- *Slope* – is the change in semitones per second from the first to the second syllable of the word that expresses the emotion (e.g. *an-gry*).<sup>27</sup> To calculate the slope, the highest frequency and the lowest frequency were identified and the corresponding difference in time (in seconds) between the two frequencies noted from the raw scores generated by Multi-Speech. From the frequency difference between the higher and lower notes, the number of semitones was then calculated using a logarithmic transformation to the basis of the 12<sup>th</sup> root of two (which is the frequency difference of one semitone). The number of semitones was then divided by the time difference (in seconds) between the highest and lowest pitches to obtain a measurement of slope in semitones per second. The formula that was used is given in Appendix 10.20.

Data screening from the sentence data identified some outlying values for the  $F_0$  and SVS of the sentence for *happy*. The highest value of each of these two variables was excluded (Appendix 10.21).

### ***Assessment of Vocal Range:***

In this task, the subjects were asked to sing the lowest and the highest note that they were able to sing. The frequencies of these two notes were measured and the interval in semitones was calculated using the same logarithmic calculation described for slope

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<sup>27</sup> Note that because sad has only one syllable, the slope between feel and sad was evaluated instead.

above. Data screening (Appendix 10.22) showed a continuous distribution. There were two peaks but no obvious skewing or extreme outliers.

#### ***Analysis of VAMS data:***

Using the VAMS, subjects reported the extent to which they felt happy, afraid, angry, sad, confused, energetic, tired, or tense. The scores can range from 0 to 100, with 0 representing the neutral face/pole and 100 representing the emotion experienced at its most extreme level. Each of the VAMS contains a vertical line, which is exactly 100 mm in length. A raw score for each scale is calculated by measuring the distance (in millimetres) between the marked point and the neutral face/pole. For example, when a subject marks the *afraid* scale line at 71 mm from the neutral face/pole, the subject's raw score on the *afraid* scale was 71. Each of the eight mood scales was assessed using this procedure.

Data screening (Appendix 10.23) of these variables showed that the responses were almost dichotomous (yes/no), as the subjects were most often marking the scale at one of the poles instead of a point between these extremes. The analyses were conducted with the original data.

#### ***Assessment of Pitch Matching:***

Ten intervals (from minor 2<sup>nd</sup> to minor 7<sup>th</sup>) were aurally presented to the subjects, and they were asked to reproduce these intervals vocally. The frequency was measured by Multi-Speech and the deviation from the target frequency calculated, both for the lower and the higher note of the interval. The absolute deviation from the target interval was then converted into semitones using a similar logarithmic transformation as previously described (Appendix 10.20).

Data screening (Appendix 10.24) of this variable showed a skewed distribution and therefore the square root of the deviation was also screened showing a less skewed distribution. The analyses reported in Chapter 6 were conducted with the original data, but repeated with the transformed data to examine how this influenced the results.

#### ***Analysis of Phrases in Songs Sung:***

One phrase from one song for each of the subjects was selected for analysis. The phrase selected was taken from the third presentation of the chorus and was a key phrase in the song, one that had a high probability of being well known to the subject. The phrase

selected from the choice of three songs was based on the phrase containing a larger vocal range than other phrases in the songs' choruses.

Each interval in the phrase was analysed using the Multi-Speech software and the absolute deviation from the target interval, expressed in semitones, was computed. Data screening (Appendix 10.25) showed some deviation from the normal distribution, which could be removed by a transformation (using the fourth root of the original data). The analyses presented in Chapter 6 were conducted with the original data, but repeated with the transformed data to examine how this influenced the results.

#### **4.12.2 Comparison of clinical and non-clinical sample**

An analysis was performed comparing the data from the clinical and non-clinical populations. This was used as a diagnostic tool to ascertain whether the pitch characteristics ( $F_0$ , SVS, slope) of spoken sentences expressing different moods (happy, afraid, angry, sad) differed between people with TBI and non-clinical subjects.

For the clinical sample, a subset uninfluenced by treatment had to be selected for this comparison. The post-session assessments after every session and also the pre-session tests of the later sessions may be influenced by the music therapy treatment program. Although only the pre-session assessment before the first session was absolutely uninfluenced by the treatment, the pre-session tests of the first five sessions were selected in order to have more data points and therefore improve test power. In total, there were 20 data points per sentence for the clinical sample (five pre-session scores for four subjects) and ten data points for each sentence for the non-clinical sample (one attempt per subject). A two-sided t-test for independent samples was used to compare the two samples.

#### **4.12.3 Case study analysis**

The data for each case were presented in a format so within-subject changes could be observed. Pre- and post-session measures for each variable ( $F_0$ , SVS, slope, vocal range, mood states, and accuracy of pitch matching) were graphed over time for each subject. Trend lines were added for ease of interpretation.

Changes in accuracy over time for pitch matching within song phrases (PMS) was also graphed for each subject. In addition, the accuracy of the different intervals in the PME and the PMS were presented alongside one another for comparison. For each

subject, the contour of the song phrase for some sessions was also graphed to show the qualitative changes in pitch control over time.

For each subject, graphs of changes to  $F_0$ , SVS and slope were compared with changes in vocal range, changes in mood, and changes with pitch matching accuracy to determine the existence of any corresponding changes between the measures.

The case studies also included analyses of the musical characteristics of the song material used in each subject's program. The analyses comprised descriptions of song text, the style, the instrumentation, the melody line (including the use of register, intervals, melody direction, phrasing and repetition), rhythm, tempo, tonality and harmony. Particular attention was also placed on detailing the type and proportion of intervals contained within the songs. Conclusions as to the overall mood of each song were provided using the crude categorisations described in Table 11.

#### **4.12.4 Cross-case analysis of outcomes**

To determine whether there were any common patterns of response across the four subjects, the subjects' individual raw data were pooled together for analysis. The analysis of therapy outcomes included:

- examination of immediate effects (pre-session to post-session differences);
- examination of longer-term effects (trends over time across all 15 sessions);
- examination of changing responsiveness to treatment (cumulative effects);

The outcomes were analysed using the following methods.

#### ***Graphical analyses***

For each variable measured, the subject's individual graphs previously presented in the case studies were presented alongside one another. Here, the data across cases were viewed to identify similarities and differences in treatment outcomes.

#### ***Effect sizes***

Effect sizes (standardized mean differences) were calculated to ascertain the size of the immediate and long term effects of treatment.

- Effect sizes for the immediate effects of treatment were calculated by dividing the difference from pre-session to post-session (using data from all sessions and all subjects) by the pre-session standard deviation.
- Effect sizes for the long term effects of treatment were calculated by dividing the difference between the first two to and the last two sessions (using data from pre-session and post-session of all subjects) by the standard deviation of the values from the first two sessions. These data were selected in order to get more data points (leading to more reliable results with higher precision and narrower confidence intervals) than if only the first and last session had been selected. All effect sizes were displayed graphically with 95% confidence intervals.

### ***Correlations between outcome variables***

To determine whether there was a relationship between the changes in subjects' moods and the sentence measures of  $F_o$ , SVS and slope, correlations between mood states and the sentence measures were undertaken. Figure 19 lists the correlations that were computed.

**Table 19. Correlations calculated in analysis**

| <b><i>Mood scale (VAMS)</i></b> | <b><i>Sentence (<math>F_o</math>, SVS, Slope)</i></b> |
|---------------------------------|---|
| happy                           | happy   |
| afraid                          | afraid  |
| angry                           | angry   |
| sad                             | sad   |
| confused                        | afraid  |
| energetic                       | happy   |
|                                 | sad   |
| tired                           | happy   |
|                                 | afraid  |
|                                 | angry   |
|                                 | sad   |
| tense                           | afraid  |
|                                 | angry   |

Each mood scale was correlated with specific sentences based on a hypothesis that varying degrees of a single mood would correlate with varying measures of  $F_o$ , SVS, and slope measures of sentences communicating the same mood or a related mood. For example, it was hypothesised that varying degrees of feelings of happiness would correlate

with varying degrees of  $F_0$ , SVS, and slope in the sentence for happy. Feelings of confusion were thought to relate most closely to fear so the sentence expressing fear (afraid) was correlated with the VAMS for confusion. Feelings of energy were thought to be positively correlated with happy and/or negatively correlated with sad. Therefore, the mood scale of energetic was correlated with the sentences expressing happy and sad. The feeling of tiredness was thought to affect all sentences and so it was correlated with all four sentences. Feelings of tension were hypothesised to affect the sentences of afraid and/or angry and therefore both these correlations were computed.

One of the research questions sought to establish whether changes to vocal range would correlate with increases in  $F_0$ , SVS and slope and therefore correlations between the sentence measures and vocal range were also computed.

It was initially planned to conduct correlations between the  $F_0$ , SVS and slope variables with those in the PME and PMS, however, data obtained in both tasks were too variable, indicating that the analysis was not likely to show any correlations. Therefore this task was not undertaken.

The clinical work and data collection underpinning this study was conducted between March 2002 and September 2002. Following this, the data were input into a personal computer, analysed by the software and then statistically treated using the analyses outlined in this chapter. The following two chapters present the results of the research. Chapter 5 presents an overview of how the reader should interpret the data presented in the results section and a section outlining the differences in clinical presentation between the subjects in the study prior to treatment and a sample of non-clinical subjects. Following this, the chapter presents a detailed description of the results for each individual case study. Chapter 6 presents the results when all subjects' data were pooled and analysed.



## CHAPTER 5

### CASE STUDIES

This chapter presents the results for each case study included in this project. For clarity in reading and interpretation, this has been divided into several parts. The first part provides a description of the terms used in the results section and a description of how the reader should interpret the figures within the results section. Following this, comparisons between the data for the clinical and non-clinical sample are reported. The next section conforms to case study presentation by detailing and discussing the results for each individual case.

#### 5.1 Interpretation of results

##### 5.1.1 Terms and abbreviations

Many different terms and abbreviations are used frequently in the results section of this thesis. In order to avoid unnecessary replication of these terms, and to provide a clear structure and nomenclature, the researcher has briefly re-stated these terms and their corresponding abbreviations and definition as they apply to the results presented within this chapter and Chapter 6.

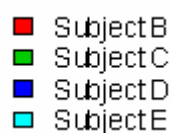
- *F<sub>0</sub>* (*Fundamental Frequency*) indicates the mean speaking frequency of a given audio sample (and corresponds to a pitch height heard perceptually);
- *SVS* (*Standardised Variability Score*) indicates the degree of semitone variability within a given phrase. The higher the SVS, the less monotonal the speaker is;
- *Slope* indicates the change in pitch over time and is measured in semitones per second. The larger the score for slope, the steeper the slope;
- *VR* (*Voice Range*) refers to the number of semitones between the highest tone and lowest tone produced;
- *PME* (*Pitch Matching Exercises*) indicates the task where the subject is required to sing specific intervals heard in isolation – that is, intervals not presented within the context of a song;

- *PMS (Pitch Matching in Songs)* refers to the singing of intervals presented within a song;
- *VAMS (Visual Analogue Mood Scale)* refers to the reporting of self-perceived mood states;
- *Pre- to post-session* refers to the measurement of change that occurs within a session – that is, the immediate effect of treatment;
- *Pre- to post-treatment* refers to the measurement of change over time, that is, from the commencement of treatment (session 1) to the completion (session 15), - ie. the long term effect.

### 5.1.2 Interpretation of figures

#### *Figures with numerical data*

A large proportion of the results presented in Chapters 5 and 6 are presented through the explanation of figures, most of which contain both raw data and overall trends. In all figures containing raw data and trend lines, a standardised format was devised to aid the reader in comparing immediate and long term responses to treatment across cases. These figures are those describing the variables of: F<sub>0</sub>, SVS, slope, VR, PME, PMS and VAMS. A colour code system was employed to identify the results of each subject (Figure 15).

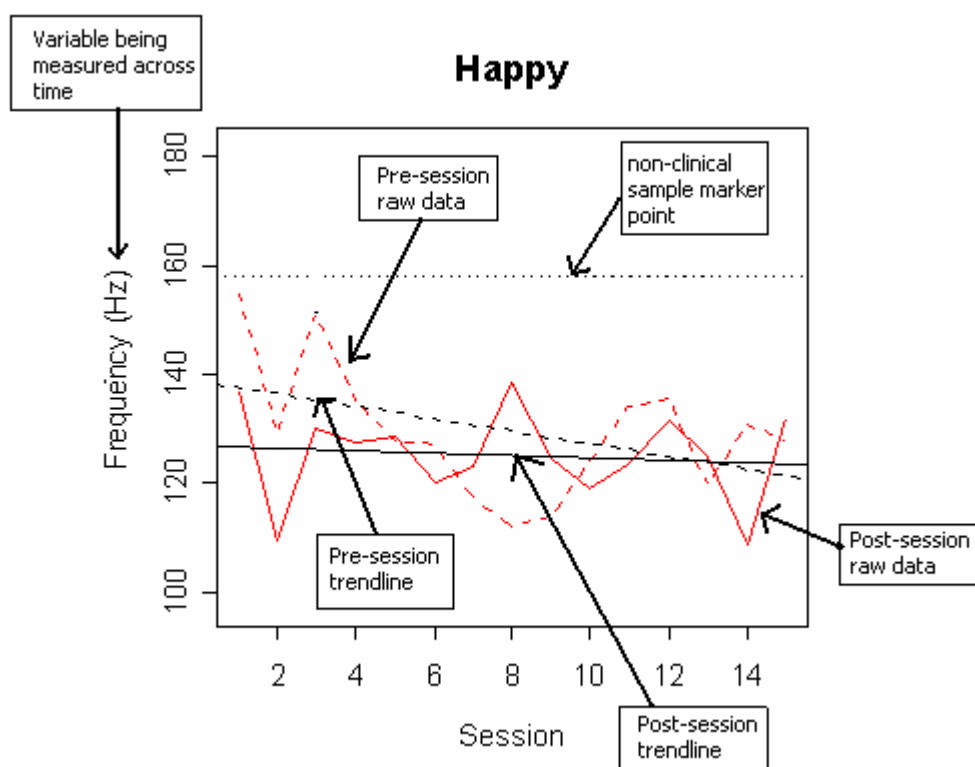


**Figure 15. Colour code key for subject results**

Figure 16 provides an example of how to interpret the graphs presented throughout the results section. Each figure has a coloured broken line (---) representing the raw scores of the *pre-session measures* and a black broken line (- - -) indicating the corresponding *pre-session trend line*. The coloured solid line (—) represents the raw scores at the *post-session* and the black solid line (—) indicates the corresponding *post-session trend line*. All figures containing measurements on F<sub>0</sub>, SVS and slope, also provide a point of reference for comparison of scores with the mean score from a trial with ten

male subjects in a non-clinical sample. It is important to note here that this point of reference, which is always printed in black with a small dotted line (·····), is not a trend over time but is a fixed point where the mean of the pooled measurements represents that task in one trial.

In these figures, the *x*-axis always represents the session number and the *y*-axis represents the variable being plotted. In the case of Figure 16, the *y*-axis represents the  $F_0$  scored in Hertz.

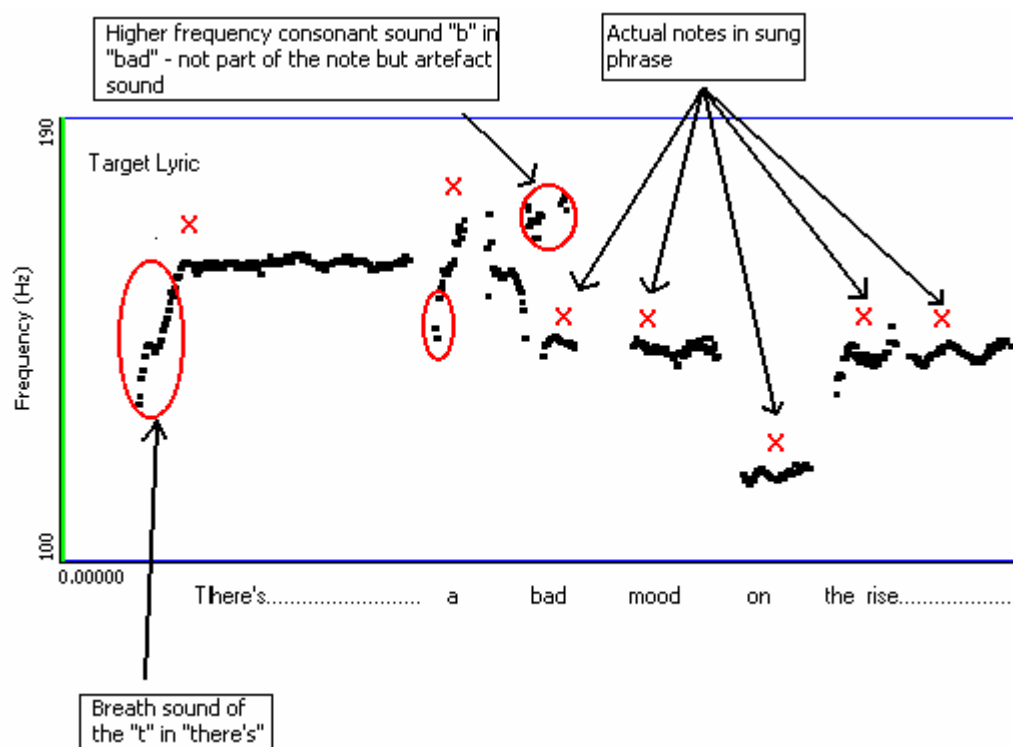


**Figure 16. Explanation of interpretations of figures**

### ***Figures with contour data***

Each of the case studies presents figures containing examples of the song contours sung by subjects within sessions and has been standardised across subjects. The first figure in each of these case studies is the presentation of the model sung by the therapist. In each contour presented, the beginning of a note is highlighted by a red **X**. High frequency sounds such as “f”, “s”, and “h” and any other artefact sounds such as that of unvoiced

breath which often occurs at the commencement of a syllable have been ringed with a red circle for easy identification (Figure 17). These are not notes but artefact sounds. The x-axis represents time with the corresponding lyrics written below and the y-axis illustrates the  $F_0$  of the vocal sounds produced. Figure 17 provides an example of the therapist singing one of the phrases to illustrate how the reader should interpret the different vocal sounds contained within the contours.



**Figure 17. Sample of song contour interpretation**

## 5.2 Comparison of clinical and non-clinical sample

To ascertain whether the four subjects included in this study were in fact clinically different from the normal population with respect to  $F_0$ , SVS and slope, the same four sentences used in the pre- and post-session sentence tasks were spoken by a group of ten males of similar age. The  $F_0$ , SVS, and slope were calculated for these sentences (total of ten data points per sentence, one attempt by each of the ten males). These results were then compared with the mean results from the first five pre-session scores for the four subjects

(total of 20 data points per sentence, five per subject) using a two-sided t-test for independent samples. Table 20 details the results of this analysis.

**Table 20. Comparison of intonation parameters for the clinical and non-clinical sample**

|               |                | Clinical (n=20) |           | Non-clinical (n=10) |           | <i>p</i> |
|---------------|----------------|-----------------|-----------|---------------------|-----------|----------|
|               |                | <i>M</i>        | <i>SD</i> | <i>M</i>            | <i>SD</i> |          |
| <i>Happy</i>  | F <sub>0</sub> | 140.31          | 14.75     | 158.41              | 11.06     | 0.01**   |
|               | SVS            | 2.22            | 1.33      | 3.27                | 1.37      | 0.06     |
|               | Slope          | 32.33           | 21.40     | 62.99               | 30.67     | 0.02*    |
| <i>Afraid</i> | F <sub>0</sub> | 125.98          | 10.15     | 125.91              | 15.36     | 0.99     |
|               | SVS            | 1.39            | 0.55      | 2.20                | 0.95      | 0.02*    |
|               | Slope          | 16.63           | 9.12      | 30.99               | 15.95     | 0.02*    |
| <i>Angry</i>  | F <sub>0</sub> | 129.14          | 12.58     | 119.58              | 35.57     | 0.39     |
|               | SVS            | 1.43            | 0.43      | 2.19                | 1.00      | 0.02*    |
|               | Slope          | 16.39           | 8.60      | 29.78               | 13.36     | 0.01**   |
| <i>Sad</i>    | F <sub>0</sub> | 121.49          | 10.76     | 117.05              | 15.33     | 0.43     |
|               | SVS            | 1.05            | 0.41      | 2.05                | 0.99      | 0.01**   |
|               | Slope          | 7.55            | 4.65      | 13.22               | 5.13      | 0.01**   |

*Note.* Significance codes: \*\*\* =  $p < 0.001$ , \*\* =  $p < 0.01$ , \* =  $p < 0.05$

Significant differences between the clinical and the non-clinical sample were found for eight of the twelve comparisons. Generally the SVS and slope scores of the clinical sample were lower than the non-clinical sample. Only the F<sub>0</sub> for happy was significantly lower in the non-clinical sample while the F<sub>0</sub> for afraid, angry and sad showed tendencies to be higher but these were not significant. Overall, these results show that these measures discriminate well between clinical and non-clinical subjects, particularly for SVS and slope.

### 5.3 Handling of missing and contaminated data

It was planned that subjects would receive 15 treatment sessions one to two times per week for five to eight weeks. Despite careful attention to obtaining a good quality recording with reliable data, due to the complexities of recording audio data in a clinical setting, some data was not able to be included in the analyses.

Human error resulted in the accidental deletion of some data. In the case of subject B, data from two sessions (sessions seven and eight) were completely deleted, with the consequence that an extra two sessions were added to the program to ensure that there was a total of 15 sessions of data to analyse. Consequently, what is described herein as session seven, is actually subject B's ninth session, his session eight is actually his tenth session, and so on.

Again due to human error, the audio data during some sessions of all four subjects was accidentally recorded in mono sound. This resulted in the vocal line of each subject being mixed together with that of the treating music therapist. In these cases, it was not possible to analyse each subject's voice during the singing of songs and therefore this material was deemed unusable and discarded. The specific sessions where this occurred are listed in Table 21.

**Table 21. Sessions with audio material mixed in mono**

|                | <i>Subject B</i> | <i>Subject C</i> | <i>Subject D</i> | <i>Subject E</i> |
|----------------|------------------|------------------|------------------|------------------|
| Session number | 4, 5             | 1, 2, 3, 4       | 1, 2, 3          | 5, 15            |

Unavoidable contaminations in the audio data occurred at points throughout each subject's program. As a result, some data was deemed unreliable and subsequently discarded. In some cases, contaminations were caused by the subjects accidentally moving the microphone away from their mouths resulting in audio signals of insufficient intensity for analysis. In other cases, ambient environmental noise distorted the audio signal. Table 22 details the number and percentage of unusable and missing data points in each variable for each subject and for the subjects' pooled results.

**Table 22. Unusable contaminated and missing data**

|                         | <i>Sentences</i>            | <i>Voice Range</i>        | <i>PME</i>                  | <i>PMS*</i>                 | <i>VAMS</i>        |
|-------------------------|-----------------------------|---------------------------|-----------------------------|-----------------------------|--------------------|
| <b><i>Subject B</i></b> | 5 (1.4%)<br><i>n</i> =360   | 0<br><i>n</i> =30         | 3 (1%)<br><i>n</i> =300     | 9 (8.6%)<br><i>n</i> =105   | 0<br><i>n</i> =240 |
| <b><i>Subject C</i></b> | 0<br><i>n</i> =360          | 0<br><i>n</i> =30         | 4 (1.3%)<br><i>n</i> =300   | 34 (32.4%)<br><i>n</i> =105 | 0<br><i>n</i> =240 |
| <b><i>Subject D</i></b> | 10 (2.8%)<br><i>n</i> =360  | 2 (10%)<br><i>n</i> =30   | 0<br><i>n</i> =300          | 12 (20%)<br><i>n</i> =60    | 0<br><i>n</i> =240 |
| <b><i>Subject E</i></b> | 9 (2.5%)<br><i>n</i> =360   | 0<br><i>n</i> =30         | 3 (1%)<br><i>n</i> =300     | 9 (15%)<br><i>n</i> =60     | 0<br><i>n</i> =240 |
| <b><i>Total</i></b>     | 24 (1.7%)<br><i>n</i> =1440 | 2 (1.7%)<br><i>n</i> =120 | 10 (0.8%)<br><i>n</i> =1200 | 64 (19.4%)<br><i>n</i> =330 | 0<br><i>n</i> =960 |

*n*= the total number of potential data points available.

\* signifies that the maximum possible number of data points were dependent upon the song used in each subject's program, this being different for each subject.

It can be seen from this table that the largest degree of missing data occurred in the PMS where 19.4% of its pooled data points were missing compared with less than 2% for all the other variables. There were no missing data points for the VAMS. The issues surrounding missing or contaminated data in this study will be addressed in the discussion.

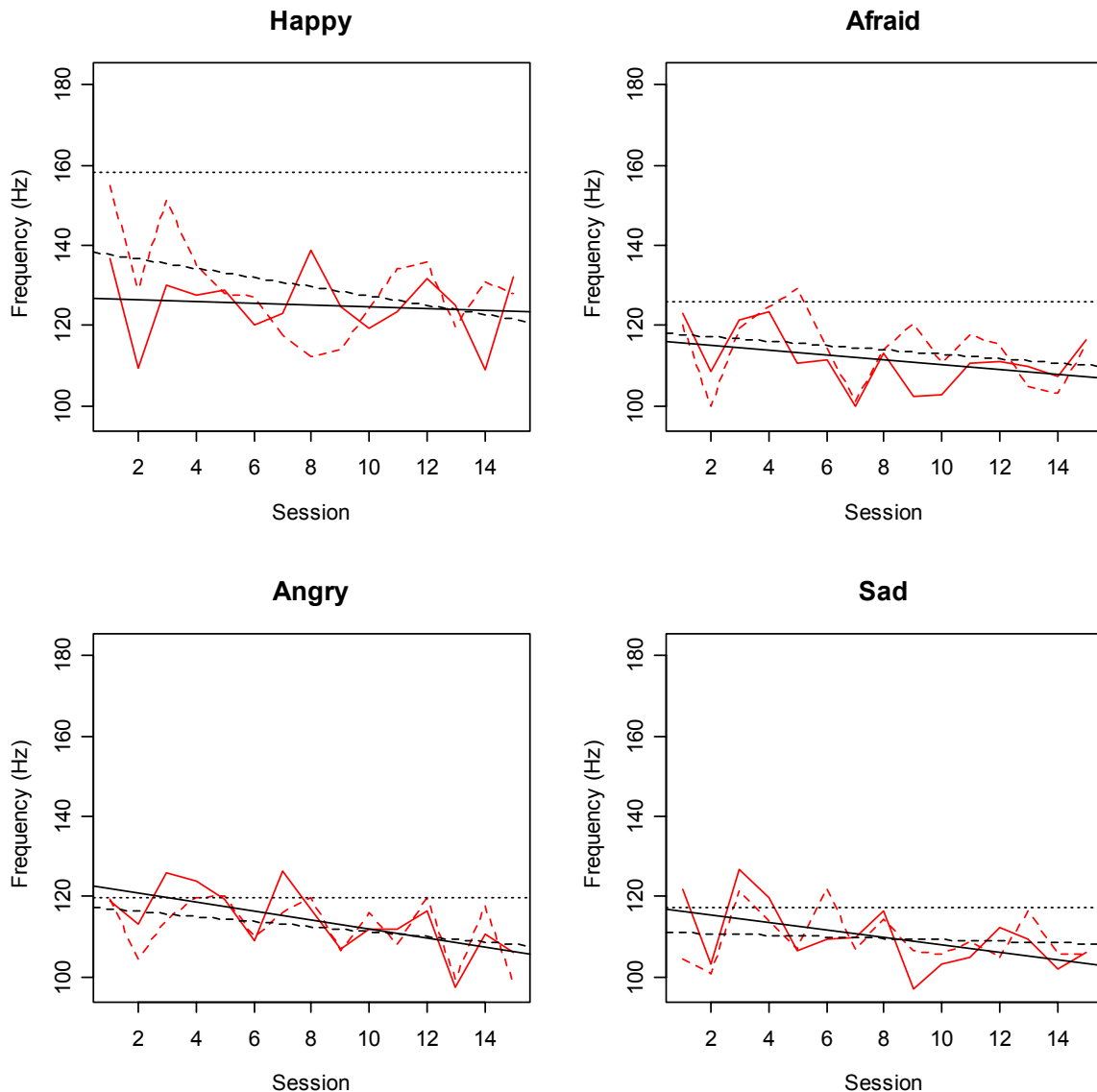
## 5.4 Subject B

### 5.4.1 Sentence measures

The following section details, and then discusses subject B's responses within the sentence reproduction tasks for the parameters of the  $F_0$ , SVS and slope.

#### *Fundamental frequency*

Figure 18 shows the immediate and long term effect of treatment on subject B's  $F_0$ .

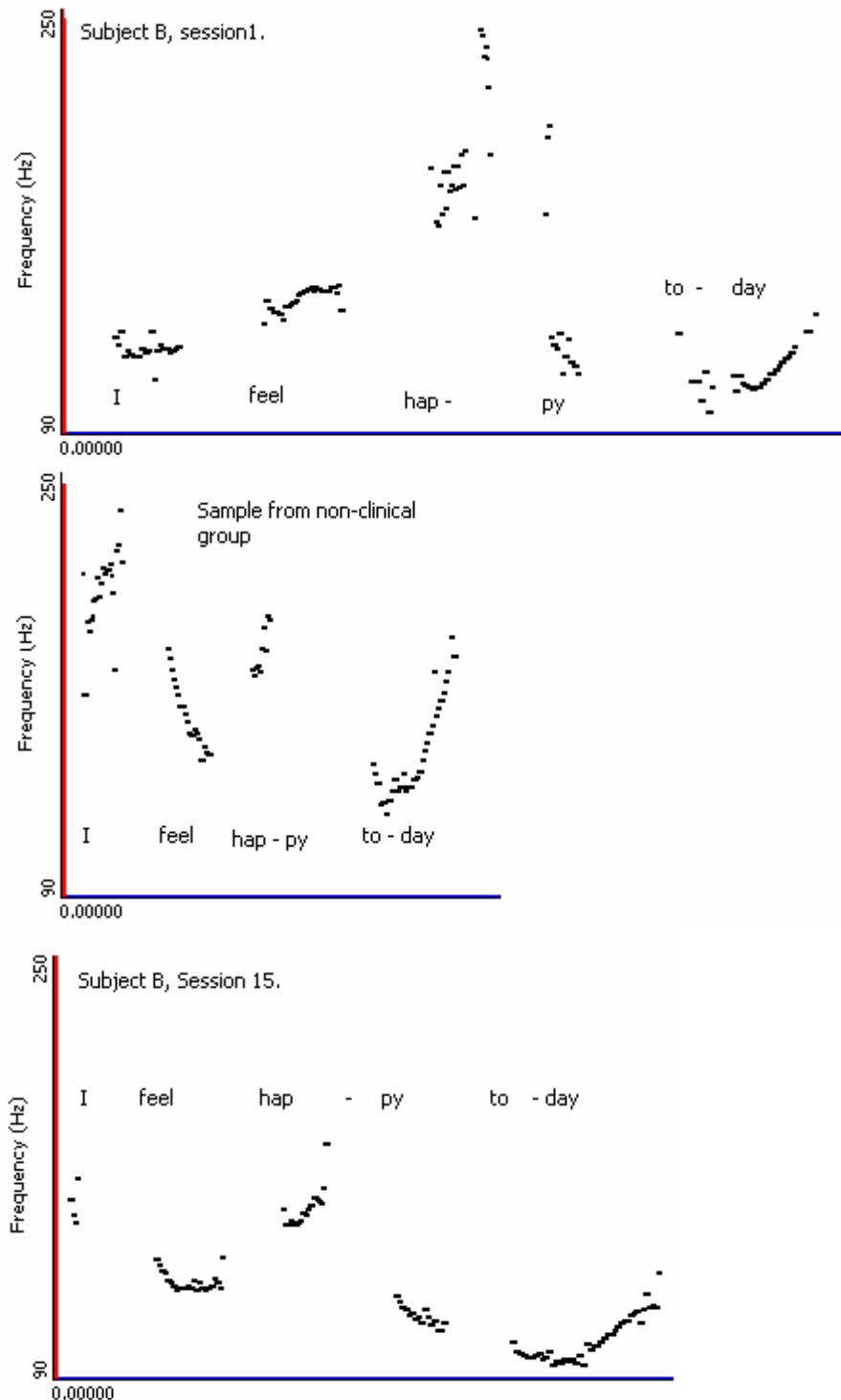


**Figure 18. Subject B: Trends in fundamental frequency**

Figure 18 illustrates that the  $F_0$  for all four sentences fell over time, and the degree of decrease was similar across all four sentences. This is viewed as a response that was contrary to the direction suggested by the literature that the  $F_0$  would increase. An over-exaggeration (use of higher frequencies) of the intonation pattern in the initial sessions resulting in a high  $F_0$  can partially explain this overall downward trend, particularly for the sentence expressing 'happy'. Figure 19 below illustrates the over-exaggerated contour for the sentence '*I feel happy today*' as spoken by subject B in session one and compares it with the same sentence spoken by:



- (a) a male in the non-clinical sample who's  $F_0$  approximated the mean  $F_0$  for the non-clinical sample, and
- (b) the final session of subject B's treatment program.



**Figure 19. Illustration of subject B's over-exaggeration of contours**

This figure highlights the over-exaggeration present in session one on the syllables *hap-py*. This exaggeration does not occur in subject B's final session or in the attempts made by the non-clinical subjects. This over-exaggeration has resulted in a raised  $F_0$  and has had a consequential influence on the overall trend analysis.

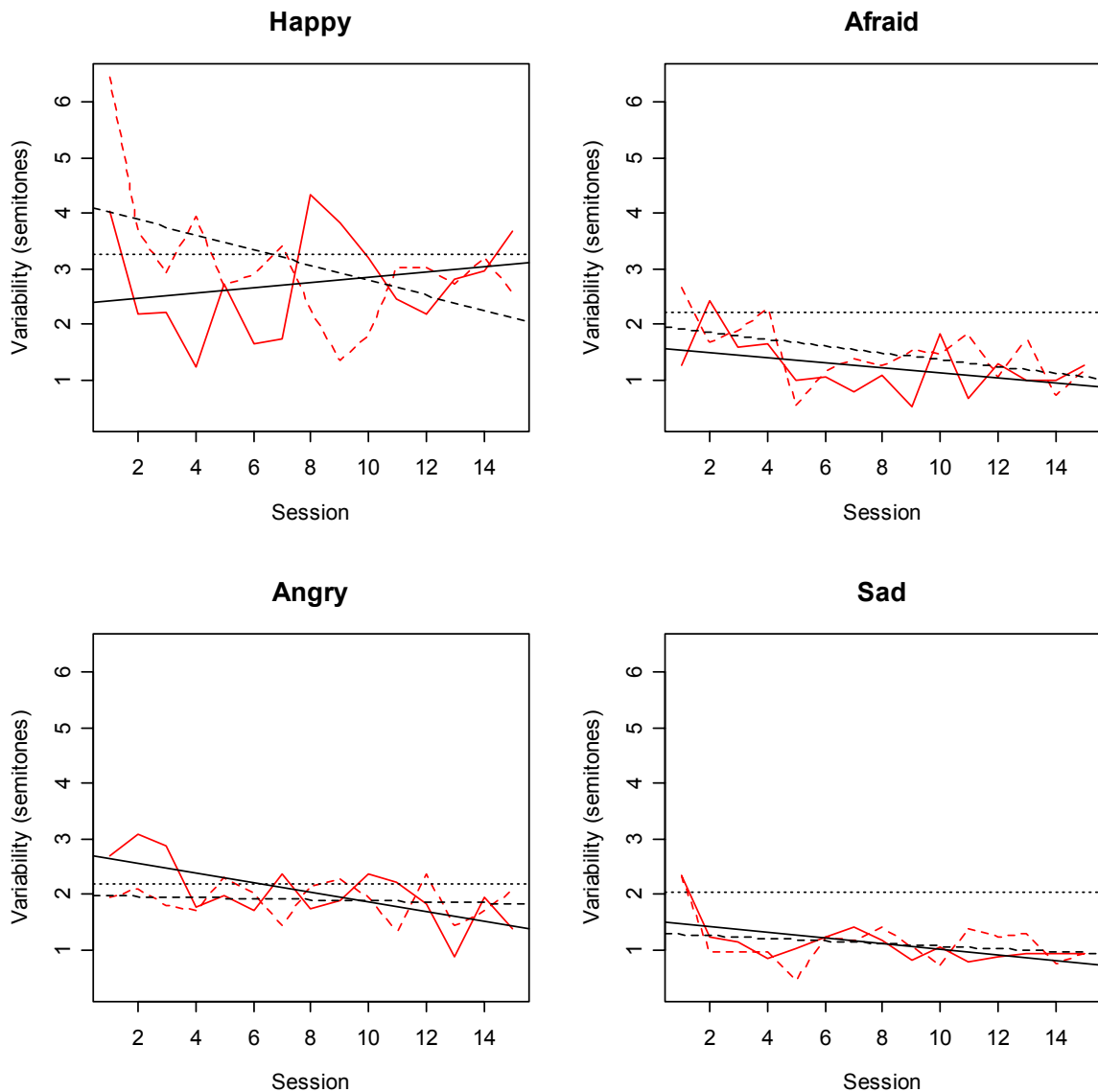
It is also noticeable that during the initial phase of the program, the  $F_0$  at the post-sessions were generally higher during the production of sad and angry when compared with the pre-sessions measures (Figure 18). However, this trend reversed during the latter half of the program. This was not apparent in the  $F_0$  for happy which displayed the reversed trend to sad and angry. The pre- and post-session trend lines for the  $F_0$  for afraid run parallel to one another with the pre-session  $F_0$  measures consistently higher throughout the program.

Subject B's responses were more consistent (showing smaller variations in responses) at the end of the program for afraid and sad, than at the beginning. Such patterns were not evident for happy and angry.

One aim of the program was to establish whether subjects were better able to use the components of intonation to differentiate between the expressions of different moods. However, there was no visible improvement in subject B's ability to apply differentiating levels of  $F_0$  to communicate the four different emotions. In fact, subject B was differentiating between the four moods to a larger degree during the initial sessions than at the end of the program.

### ***Standardised variability score***

Figure 20 illustrates the immediate and long term effect of treatment on Subject B's SVS.



**Figure 20. Subject B: Trends in standardised variability scores**

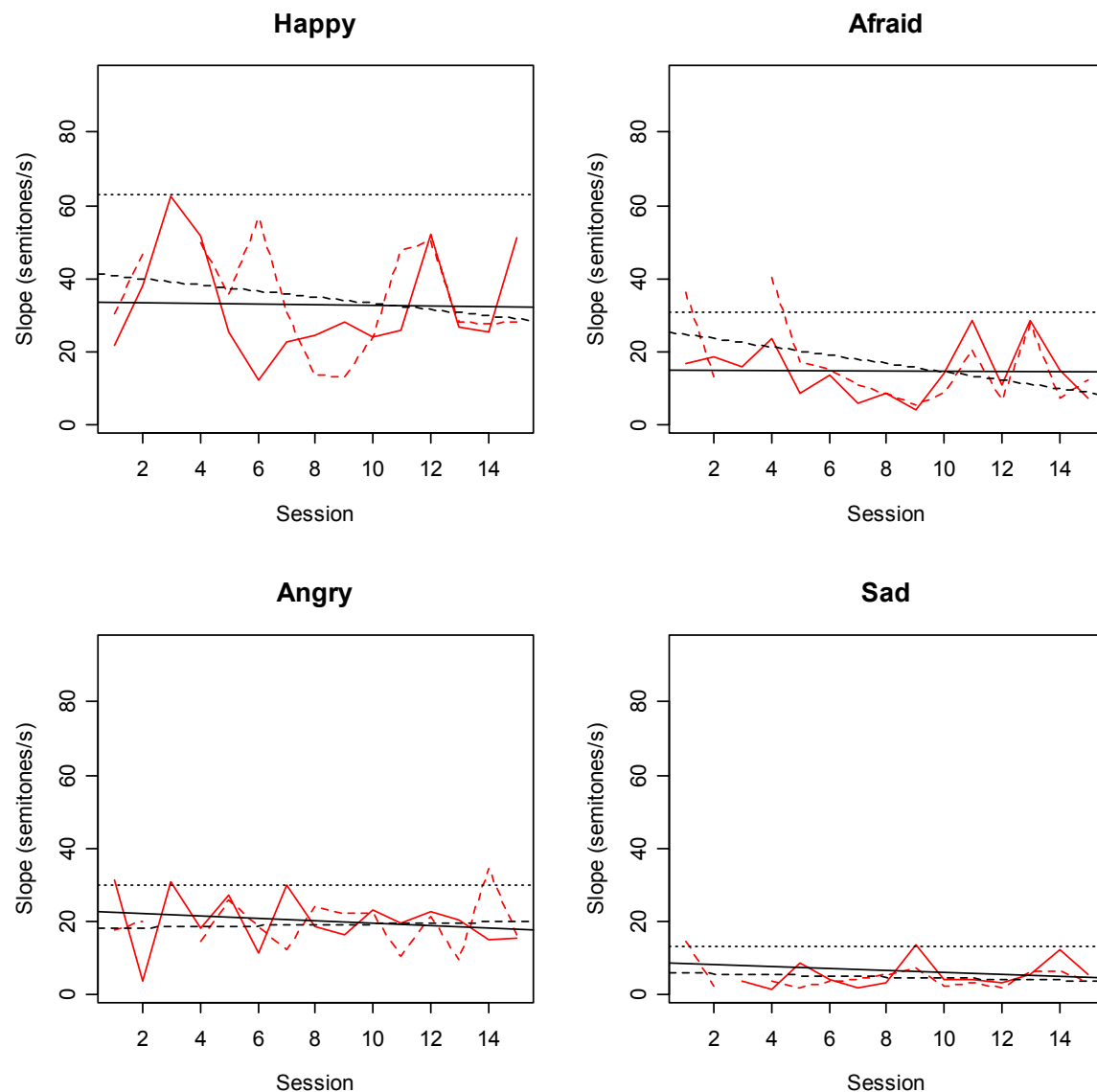
Figure 20 shows that the SVS fell over time for all four sentences, implying that subject B became more monotonal long term. Further, the differences in size of the SVS between subject B and the non-clinical group became more marked over time. The SVS for angry fell by the largest degree whereas the SVS for sad decreased only slightly. As with the  $F_0$  measures, some of the initial sessions were characterised by an over-exaggerated vocal intonation pattern, particularly for happy. This factor strongly influenced the direction of the trend lines, which were in the direction contrary to that expected.

Differences between pre- and post-session scores depended on the sentence. The SVS for angry and sad were initially larger at the post-session with this trend reversing towards the final phase of the program. In contrast, the SVS for happy were larger in the pre-session, this trend reversing in the latter part of the program. The pre- and post-session trend lines for the SVS for afraid run parallel to one another with the pre-session SVS displaying consistently higher SVS throughout the program.

The consistency between the pre- and post-session responses (variability) and between the sessions, increased over time. These increases in consistency were similar across the four sentences. In using the SVS as an expressive intonation tool, there appears to be no long term change in subject B's ability to differentiate the expression of emotion across the four sentences.

### ***Slope***

Figure 21 illustrates the immediate and long term effects of treatment on subject B's production of slope for the four sentences.



**Figure 21. Subject B: Trends in slope measures**

As was evident for  $F_0$  and SVS, the production of the slope for the syllables *hap-py*, *a-fraid*, *an-gry*, and *feel-sad*, all decreased over time, this being a response contrary to that suggested by the literature for angry, happy and afraid, but in the direction anticipated for sad. The post-session assessment of slope for the syllables *feel-sad*, was consistently steeper than the pre-session, a trend not evident in the  $F_0$  and SVS data. For angry, the post-session measures were steeper than the pre-session measures in the initial stages of the program, this pattern reversing during the latter half of the program. For happy, the pre-session slopes were steeper in the initial phase of treatment, with a reverse pattern emerging later in the treatment.

It is unclear whether the influence of over-exaggeration highlighted in the data for  $F_0$  and SVS in the earlier sessions influenced the trend lines for slope. Consistency in scores did not seem to alter over time, with the slope for happy showing the widest variability in responses.

It can be seen in Figure 21 that the non-clinical sample showed a clear differentiation between the four sentences in their use of slope. In comparison, subject B became less able to use varying degrees of slope to differentiate between the different emotions.

### ***Discussion of sentence measures***

The speech pathology assessment reported that subject B had a lower than normal speaking  $F_0$  and that his use of pitch in speech was limited. Subject B was also reported to have displayed a moderate impairment in creating expressive intonation patterns and was therefore at risk of his emotional state being misunderstood. Conversely, when compared with the non-clinical sample, the raw data showed that some individual measures ( $F_0$  and SVS) equated to or were close to the non-clinical sample during the initial sessions of the program. The exception was the SVS for happy, which was measured as larger than the mean of the non-clinical sample. Therefore, there were inconsistencies between the speech pathologist's subjective assessment of subject B's clinical presentation and that evaluated with the software analysis program. To complicate matters further, the family reported that subject B's voice was low-pitched, deep, and moderately monotonal pre-trauma and had become higher in pitch and less monotonal post-trauma.

The large measures obtained in the earlier sessions can be explained by subject B's over-exaggeration of the intonation contours. There could be a number of explanations for this.

Firstly, subject B may have been unsure how to artificially inflect a feeling into a sentence, this resulting in his over-estimating his use of pitch range.

Secondly, he also may have underlying expectations that he should perform well for the treating music therapist and given that the reason for his participation in the program had been explained to him, he may have been trying hard to achieve the less monotonal effect that the program was designed for. A similar phenomenon occurred in the first case described by Cohen (1995) where her client displayed a large SVS ( $F_0$

variability) in the first session but this decreased dramatically in the second session, with the initial level of SVS not seen again at any point during the program.

Thirdly, he may have been highly motivated at the beginning of the program inserting extra effort in his production of the tasks, and in doing so, over-exaggerated the contours. Further, his possible fluctuation in motivation may be one of the underlying explanations for the high variability in responses as evident by the frequent presence of peaks and troughs in the raw data lines.

In general, these results reveal that subject B's  $F_0$ , SVS, and slope decreased over the course of treatment- perceptually indicative of lower-pitched and more monotonal intonation (q.1). Further, there was no apparent change in his ability to differentiate between the different emotions expressed across all three vocal parameters (q.4). It also suggests that he was less able to inflect appropriate emotion into his speech than at the beginning of the program. This was not the desired outcome, as now subject B may have more difficulty in expressing his intended emotion thereby being at risk of being misunderstood, and less able to engage a listener. However, as the family report indicated that his pre-trauma voice was lower and more monotonal than his post-trauma voice, these gradual decreases in  $F_0$ , SVS, and slope are considered a good outcome in assisting subject B to return to his pre-trauma self.

From a physiological perspective, there may be other reasons why subject B's  $F_0$  decreased with time. Research states that a lower  $F_0$  is indicative of lower tension in the vocal folds (Leonard et al., 1988). Given subject B's trend for his  $F_0$  to fall over time, it suggests that a lowering in tension occurred as a long term consequence of the program, this then transferring into an overall lowering of the  $F_0$ . A flaw in this argument is however, that one would expect a corresponding increase in SVS (and perhaps even slope) to occur, which in subject B's case, it (or they) did not. A lowering of vocal tension results in enhanced flexibility of the vocal folds and therefore a greater potential for larger SVS and slope in speaking. Alternatively, a lowering of  $F_0$ , SVS and slope could also be indicative of fatigue. When people tire, this is reflected in vocal fold behaviour - the body tends to activate muscle behaviour that uses the least energy. This reduces the degree of tension/relaxation in the vocal folds, resulting in a lowering of  $F_0$ , restricted SVS and flatter slopes, compared to periods when fatigue is not evident (Aronson, 1990; Bunch, 1997; Pittman, 1994; Stengel & Strauch, 2000). These points will be revisited when discussing subject B's responses in the VAMS.

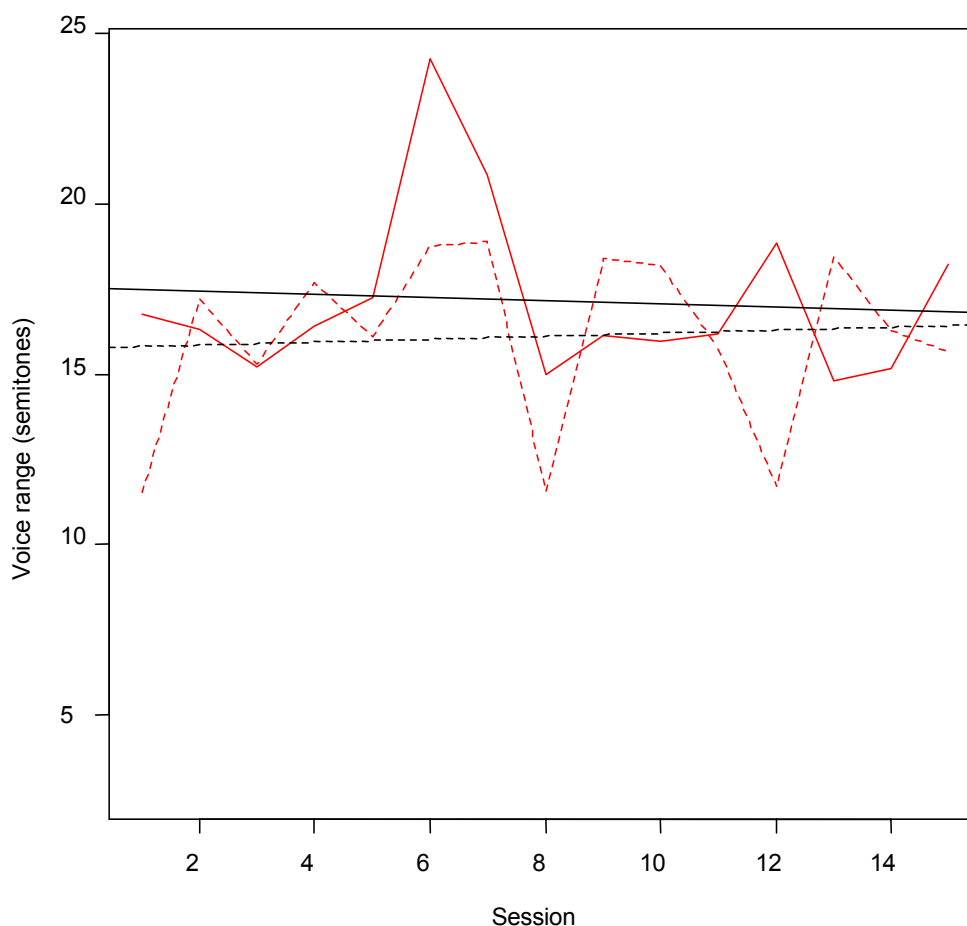
Subject B's immediate and long term responses to treatment were different for the four sentences and for the three parameters measured. The only patterns to emerge were that the immediate effects of treatment were in the direction contrary to that expected (pre-session scores were higher) for all three parameters ( $F_0$ , SVS, and slope) during the production of the happy and afraid sentences. This shows that subject B was generally lower in vocal pitch and more monotonal at the end of the sessions. In contrast, for angry and sad, the parameters were typically higher and larger at the post-session, indicating that subject B was higher in pitch, less monotonal and therefore, more expressive in his speech.

In conclusion, the responses produced by subject B indicate that his treatment did not increase his speaking  $F_0$ , SVS and slope. However, these results indicate that his speaking voice approached his pre-trauma vocal style, which was characteristically low in pitch and monotonal.

#### **5.4.2 Vocal range**

The next section reports and discusses subject B's changes in VR and how these changes relate to intonation measures. Figure 22 illustrates the immediate and long-term changes in subject B's VR.





**Figure 22. Subject B: Trends in vocal range**

The long term effects of treatment illustrated in Figure 22 show that the VR became slightly higher at the pre-session (approximately one semitone), and slightly lower at the post-session (less than one semitone) (q.2a). It is clear from this figure that the unusual peak evident in session six influenced the post-session trend. Contamination of the audio signal is a possible explanation for this.

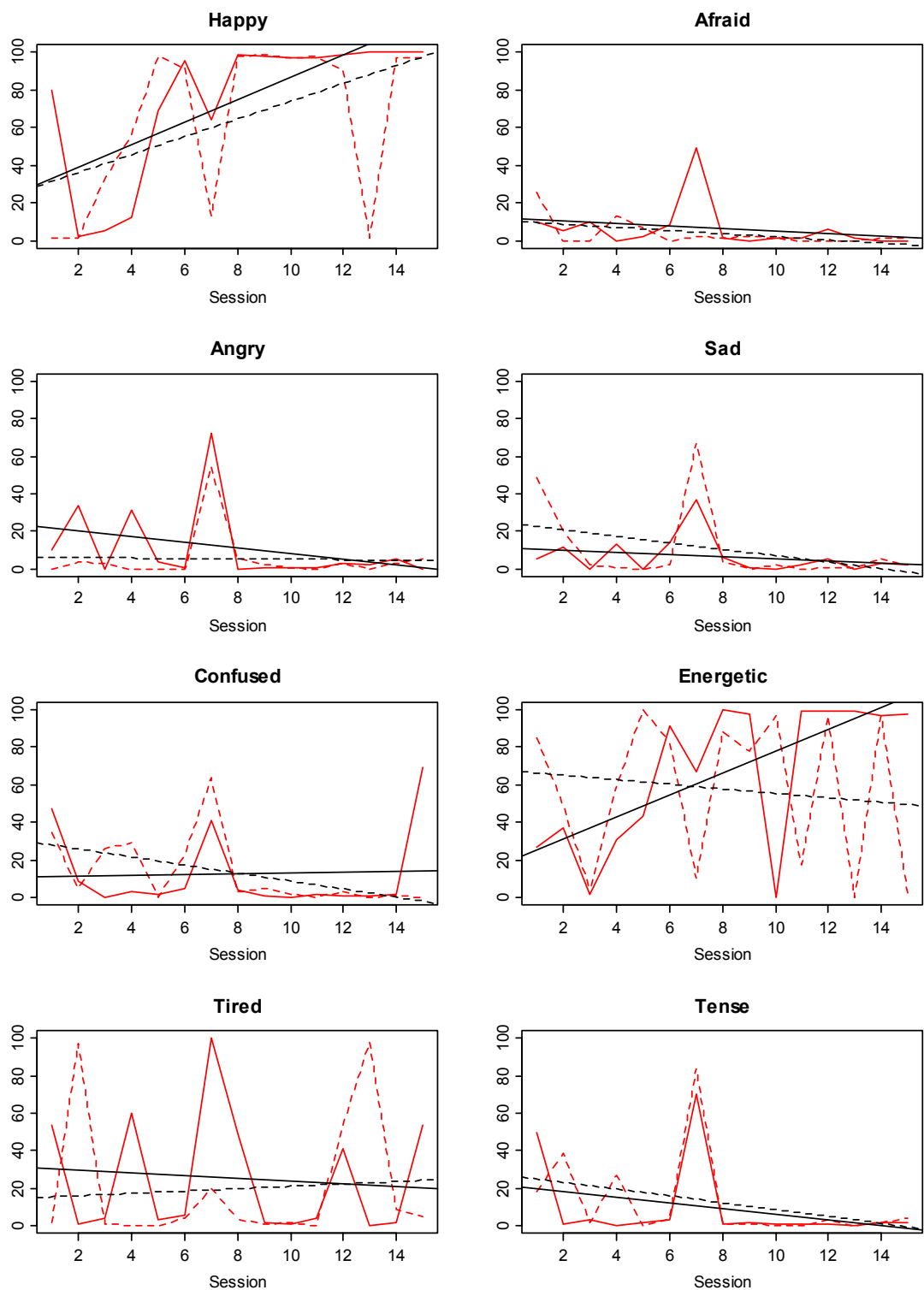
It was also noticeable that the post-session VR was higher than the pre-session VR signifying that the immediate effects of treatment were in the direction opposite to that suggested by previous literature (q.2a). However, these results should be interpreted with caution given the high variability in responses between sessions. For example it can be seen that during session seven, the pre-session VR was approximately 18 semitones. The following session (session eight), the pre-session VR fell to approximately 11 semitones and then was raised again to about 18 semitones in session nine. Such variations in subject B's VR may be a consequence of varying degrees of concentration, motivation and fatigue typical of TBI (Bowen et al., 1998; Prigatano, 1999a) or of varying degrees of vocal tension (Leonard et al., 1988).

***Discussion of vocal range and sentence measures***

Results indicate that as the VR slightly increased long term, the  $F_0$ , SVS and slope decreased (q.3a). Therefore, for this subject, an increase in VR was not a predictor of an increase in SVS, slope and  $F_0$  and therefore, not an indicator of an enhanced potential for expression.

**5.4.3 Visual analog mood scale**

The next section reports and discusses the immediate and long term effects of treatment on subject B's reported mood changes and how these relate to the changes in intonation measures. Figure 23 displays subject B's reported mood changes pre- and post-session and over time.



Key: x-axis = session number, y-axis = VAMS score (out of 100).

**Figure 23. Subject B: Trends in visual analog mood scale scores**

Figure 23 shows that immediate effects were often characterised by polarities in responses – particularly for the mood scales of happy, energetic and tired. Generally, subject B became happier, more energetic, but also more tired from pre- to post-session. He also became angrier, and less sad at the post-session when compared with the pre-session. This suggests an overall increase in positive affect.

Long term reported measures indicate that subject B became happier, more energetic, less angry, less tense, less afraid, less sad, and less confused. It is noticeable that there was a generalised flat affect reported for the sad, tense, afraid and confused scales.

When viewing the data across the eight mood scales, it is noticeable that subject B reports a strong emotional response in session seven. At the pre-session, he reports strong feelings of sadness, anger, tension and confusion. At the post-session, feelings of tension and anger remain high. There is a slight decrease in confusion and sadness but an increase in fear and happiness. Tiredness increases to the largest degree, which is probably not surprising, given that experiencing the intensity of these feeling states is in itself tiring.

### ***Discussion of mood and sentence measures***

As mentioned above, subject B reported large swings in his mood particularly for the mood scales of happy, tired and energetic (q.2b). This might suggest that subject B had difficulty in accurately measuring the level of intensity of his feelings. For instance, if he felt happy, he scored on or near 100 on the score sheet, and if he did not feel happy, he scored on or near zero. Similarly, the fact that he rarely scored more than zero for the remaining mood scales (with the exception of session seven), might point to an inherent post-trauma difficulty in identifying and measuring mood. A lack of self-awareness and poor insight are commonly reported impairments of people with TBI (Oddy et al., 1985; Prigatano, 1999b; Prigatano & Schacter, 1991). Because subject B was able to identify feelings on the happy, energetic, and tired scale might suggest that it was easier for him to identify experiencing these feelings, therefore scoring polarities in the scores for these three scales.

Comparing the figures describing  $F_0$ , SVS, and slope (Figure 18, 20 and 21), with the figures illustrating changes in mood (Figure 23), it was observed that subject B became more monotonal and less sharp in his changes in frequency (slope) and spoke with a lower overall pitch height when his mood became more neutral (q.3b). The exception to this is the relationship between increases in reports of happiness and energy and corresponding

decreases in  $F_0$ , SVS and slope. However, the links between mood and  $F_0$ , SVS, and slope should be interpreted with caution given the generally flat affect reported on most scales.

When examining session seven, it was noticeable that there was an increase in affect across many mood scales. However, no consistent corresponding increase or decrease in  $F_0$ , SVS and slope was evident.

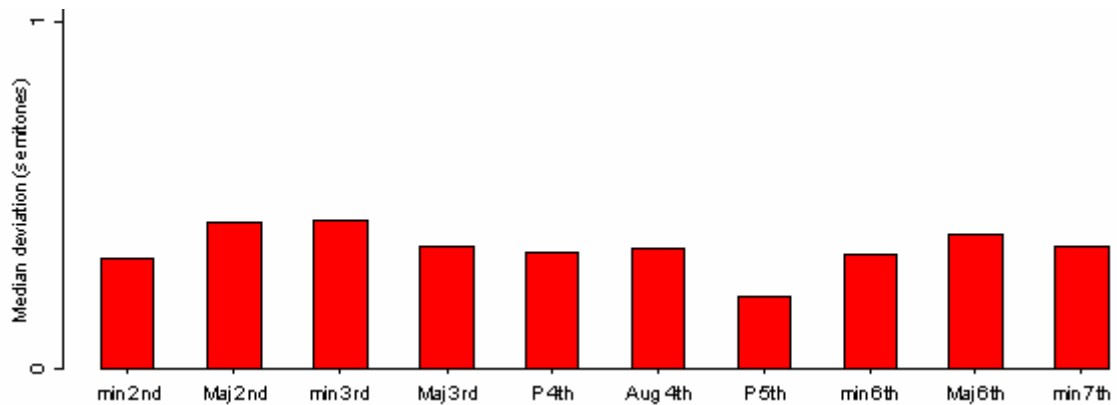
When observing the more long term changes in mood and the responses within the sentence tasks, it appears that a relationship exists that is contrary to that expected. Here, there is a noticeable decrease in  $F_0$ , SVS and slope over time, and a corresponding increase in feelings of happiness (q.3b). According to Alpert et al. (2001), Frolov et al. (1999), Garcia-Toro et al. (2000) and Kuny & Stassen (1995), a lower  $F_0$ , SVS and slope is suggestive of a depressed mood and not an elevated mood as in subject B's case. It was also mentioned earlier that increasing levels of fatigue could explain the long term decrease in  $F_0$ , SVS and slope. However, subject B did not report such increases in fatigue.

#### **5.4.4 Pitch matching in exercises and songs**

The following section reports and discusses the findings regarding subject B's ability to sing intervals within PME and within song phrases (PMS). The first section reports on the PME where subject B was asked to produce intervals played to him on a CD. Two measures are described here – the differences in accuracy between the different intervals, and the immediate and long term changes in the accuracy of interval production. The second part of this section details subject B's performance of intervals sung within song phrases. It begins with a description of all the songs used in the program, followed by a description of the song and phrase chosen for analysis. Next, there is a brief report on subject B's accuracy in singing the different intervals contained within the target phrase. Following this, long term changes in accuracy of interval production are presented. This leads onto the qualitative analyses of the song phrase contours. The third part of this section provides a comparison between subject B's performance of the intervals within the PME and within the PMS. Finally, this section concludes with a brief discussion concerning these findings and their relevance to subject B's performance in the sentence production tasks ( $F_0$ , SVS and slope).

***Pitch matching exercise***

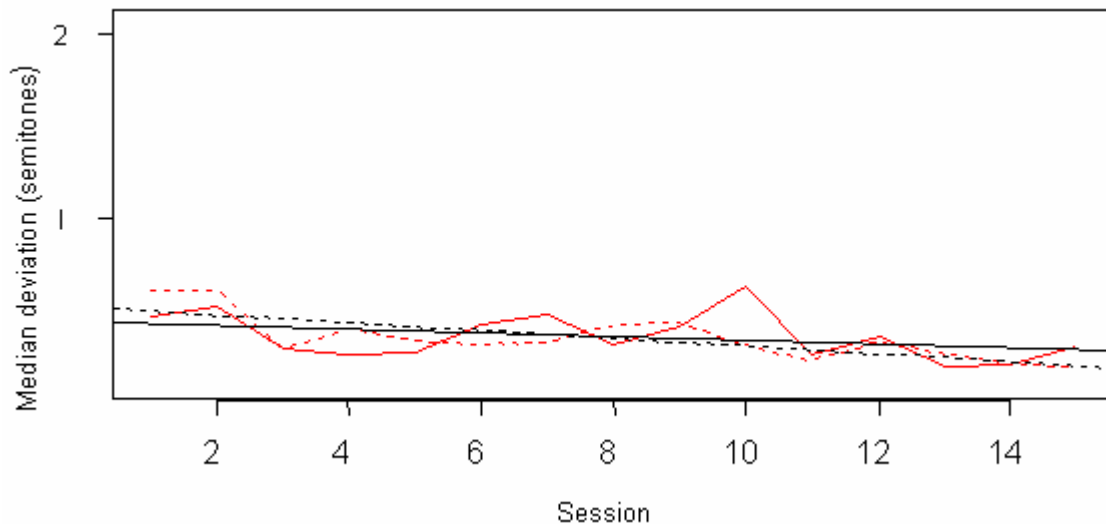
Figure 24 illustrates how subject B differed in his accuracy of reproduction across different intervals. Here, the y-axis reports the median number of semitones subject B deviated above or below the target reproduction of each interval.



**Figure 24. Subject B: Differences between intervals in pitch matching exercise**

Figure 24 shows that subject B was generally accurate in his production of intervals (less than half a semitone deviation from the true interval) when they were heard in the context of an exercise. It can be seen that the perfect 5<sup>th</sup> was sung particularly well and there was little noticeable difference in accuracy between the other nine intervals.

Figure 25 details the immediate and long term changes in pitch matching accuracy when the data from all the intervals were pooled. Again, the y-axis reports the median number of semitones subject B was away from accurate interval reproductions.



**Figure 25. Subject B: Trends in pitch matching exercise**

Figure 25 illustrates that subject B slightly improved in his ability to produce intervals over time suggesting he was better able to control his pitch (q.2c). A slight improvement is considered a positive result given that subject B was already highly accurate in his production of intervals. Pre- and post-session scores were similar across the program, with no real difference between the two noted.


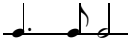
### ***Pitch matching in song phrases***

The three songs selected by the music therapist from a short list of subject-preferred songs as given by the subject and his family were:

- *I heard it through the grapevine* performed by Creedence Clearwater Revival
- *Comfortably numb* performed by Pink Floyd
- *Under the bridge* performed by artist The Red Hot Chili Peppers

*I heard it through the grapevine* is a song from the 1960's containing three verses and a chorus. The lyrics focus on the thoughts and reflections of a man who discovers that his girlfriend has been seeing another man. The song has a feeling of sadness and longing set in a Blues style. The tonality is predominately minor (in D) and moves between four chords (D minor, G major, A major and B minor). Typical of a blues style, the song has a static melody and although it expands the range of 1.5 octaves (17 semitones), the melody is principally limited to a perfect 5<sup>th</sup> (D<sup>3</sup> to A<sup>4</sup>). Large intervals are infrequent with the

single use of an octave, a perfect 4<sup>th</sup> and a perfect 5<sup>th</sup> in each verse and no interval greater than a minor 3<sup>rd</sup> in the chorus. The minor 3<sup>rd</sup> is the most prevalent interval in this song. The rhythmic feel to this song is static as conveyed through a repetitive quaver rhythm. The rhythm and fast tempo almost appear to resemble a fast heartbeat. When considering this description, the song would be classified as sad, restless and agitated according to the parameters described in Table 11.

*Comfortably numb* is a song from the 1980's that is about someone in a severely drugged altered state who has this state reversed by a medical intervention (as described by the lyrics *You will feel a little prick, you may feel a little sick*). The title itself *Comfortably numb* is itself a metaphor for the feeling induced by drug use. The song conveys feelings of pain through the tension and release created mainly by its chordal progressions. Here, long and sustained unresolved harmonies are eventually resolved. The verses in this song are centered in the key of B minor and the chorus in D major. This harmonically rich song moves through chordal progressions containing the chords of D major, C major, E minor, F<sup>#</sup> minor, G major, A major, and B minor. The melody line extends over an octave (from A<sup>3</sup> to A<sup>4</sup>) with frequent and large melodic movement in the verse including intervals of an octave and minor 7<sup>th</sup>. The chorus has a more melodically static feel using mainly stepwise motion (minor 2<sup>nds</sup> and major 2<sup>nds</sup>). The tempo of the song is slow and there are two predominating rhythmic patterns – the  and . According to the criteria presented in Table 11, this song creates a mood of sadness, confusion and pain.

The song selected for analysis from the three songs used in subject B's sessions was *Under the bridge* written and performed by The Red Hot Chili Peppers, an American rock band popular in the mid to late 1990's. This song was selected from the three used in his program because the key phrase in that song (Figure 26) contained the largest pitch range (within a major 6<sup>th</sup>) when compared with the other songs. The pitch range for the key phrases in *I heard it through the grapevine* is a minor 3<sup>rd</sup> and in *Comfortably numb* is a perfect 5<sup>th</sup>.

*Under the bridge* contains intervals of varied size from stepwise motion, to interval jumps of a minor 7<sup>th</sup>. The total range of the song extends to a major 12<sup>th</sup> (19 semitones) and the melody is generally characterized by frequent movement up and down within this melodic range. While the melodic line is predictable and easy to recall, it is also difficult to sing because of the large and frequent leaps. The original recording of the song has a mixture of rock and ballad styles, with a fast driving tempo. There are also occasional



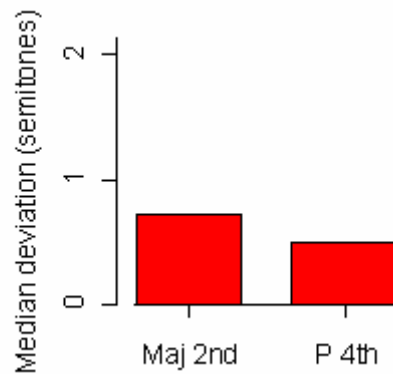
pauses of silence before moving between verse and chorus. The song's theme is about being alone and has drug dependency themes with several references to the illicit taking of intravenous drugs (for example – *Under the bridge downtown, is where I drew some blood*). It has a yearning feel to it, as if to be detoxing. With the metaphor *Under the bridge downtown, I threw my life away*, the song portrays the psychological, personal and socio-economic damage that arises from the abuse of illicit drugs. Harmonically, the song is predominantly built around E major in the verses and modulates to C<sup>#</sup> major in the chorus. Chordal progressions are generally predictable. Rhythmically the song is in common time with simple rhythms. An analysis of the musical parameters suggests overall that the song expresses agitation, restlessness, frustration and to some extent a feeling of desperation.

The key phrase analysed for pitch accuracy was *Take me all the way – ay, yeh, yeh* (Figure 26). This is the final phrase of the chorus, and the phrase most likely to be well known by subject B. It is characterized by a moving melodic line and has an almost staccato feel to the sung style. It contains seven intervals (a perfect 4<sup>th</sup> and six major 2<sup>nds</sup> intervals).



**Figure 26. Subject B: Selected song phrase for analysis**

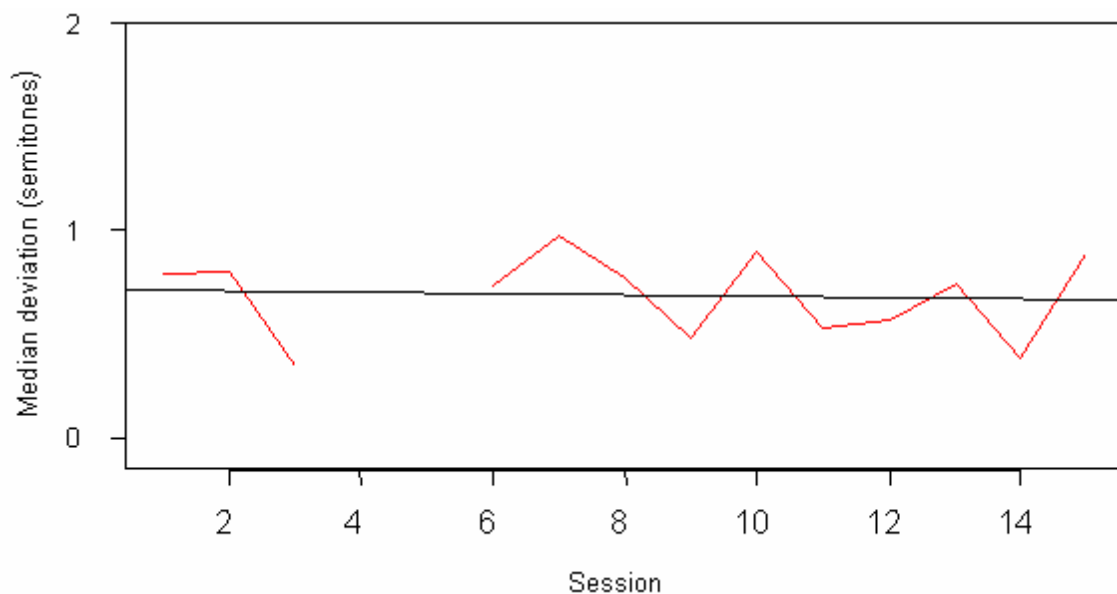
Figure 27 illustrates subject B's degree of accuracy in his singing of the two interval types. As in the PME, the y-axis reports the median number of semitones subject B was away from accurate interval reproduction.



**Figure 27. Subject B: Differences between intervals in song phrases**

The results indicate that subject B's deviation was less than one semitone for the production of both intervals contained within the song phrase. He was more accurate in his production of the perfect 4<sup>th</sup> when compared with the major 2<sup>nd</sup>, a trend that was also evident in the PME.

Figure 28 details the immediate and long term changes in the singing accuracy of intervals contained in song phrases when the data from all the intervals were pooled. As before, the y-axis reports the median number of semitones deviated from the target.



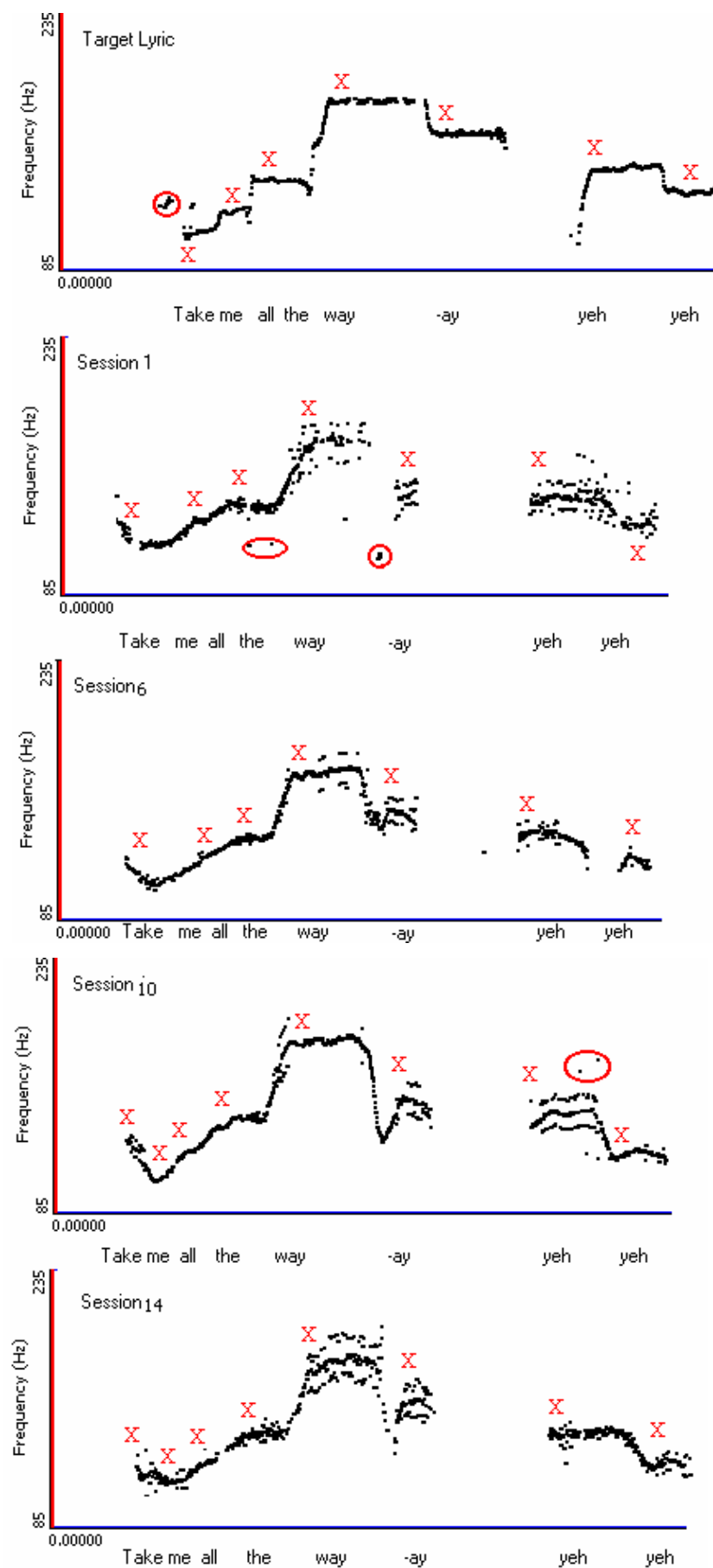
**Figure 28. Subject B: Trends in pitch matching in song phrases**

Figure 28 illustrates that there was a small increase in the accuracy of interval pitch matching over time, which is consistent with the improvements observed in the PME. This suggests that there is some relationship between increases in accuracy in PME and accuracy in producing intervals within song phrases.

### ***Analysis of song contours***

This section documents the results of the contour analysis for the song phrase *Take me all the way, yeh, yeh* sung during four sessions (sessions one, six, ten and fourteen). It was intended that sessions one, five, nine and fourteen were to be analysed, however the song material from session five was contaminated due to human error, and therefore not able to be analysed. The researcher selected session six as an alternative. Given that session six and session nine were in close succession, it was decided to also analyse session ten rather than session nine. The final session (session fifteen) was not analysed as it was considered that subject B might not perform at his greatest potential, this being the final session of the treatment program.

In Figure 29, the first contour (top) is the target phrase sung by the therapist, who gives the most accurate reproduction of the phrase. The contours below the therapist's illustrate subject B's singing for the phrase during one, six, ten and fourteen.



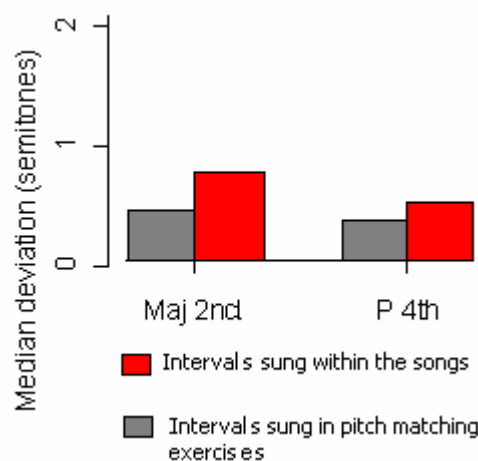
**Figure 29. Subject B: Contours for selected song phrase**

Figure 29 shows that when the song phrases were graphically represented and compared with the target, a progressive improvement in pitch control can be seen (q.2c). In session one, it can be seen that subject B used a vocal sliding motion to search for the target pitch. This is observed in moving from the word *the* to *way* and from the word *yeh* to *yeh*. The increase in control can be seen in session ten whereby subject B used a sharper and more distinct movement from one pitch (*the*) to another (*way*). The note pitches achieved in session ten also tend to be higher and more accurate in pitch height when compared with earlier examples. Further, the purity of the sound is also markedly better here, the contours of the earlier sessions characterised by vocal noise, which is an indicator of poor control. It can also be observed here that he is able to sustain the pitch of this note with a reasonable level of control (that is, he maintains a constant frequency).

In session fourteen, the same observation is evident in the final two syllables where the pitch on the first syllable *hey*, is sustained in a clear and controlled manner when compared with the earlier sessions.

### ***Comparison between pitch matching exercises and pitch matching in songs***

Figure 30 compares the subject B's accuracy in singing the two intervals within the PMS with those in the PME.



**Figure 30. Subject B: Accuracy differences between pitch matching exercises and pitch matching in songs**

When a comparison was made between the intervals sung in the PME and those in the PMS, it was found that subject B was less accurate singing intervals within the phrase of a song. Even though these differences were small, several reasons may underlie this finding. First, subject B may have been more engaged in the singing during the PMS, enjoying the activity rather than focusing on singing accuracy. The automatic nature of song singing has been reported previously in the music therapy literature whereby little attention is required to perform the task (Baker, 2000). Further, subject B may have perceived the PME as an assessment thereby applying more concentration when completing this task and consequently being more accurate in his production of the intervals.

The degree of accuracy in pitch matching might stem from the amount of preparation time required by people with TBI to perceive, process and then activate their response. Perhaps singing intervals within a PME may have allowed subject B more time to prepare for his performance of the task when compared with singing songs. The fact that the target interval within the PME was played twice gave subject B an opportunity to mentally prepare for each interval reproduction. No such preparation was possible in the singing of phrases within the song, the song moving at a faster tempo with several intervals required to be sung in fast succession. The variable of rhythm and tempo might have been an influencing factor in the PMS, this being absent in the PME.

### ***Discussion of pitch matching in exercises, songs and other measures***

Results concerning the PME and PMS show that subject B improved his pitch control over the course of treatment (q.2c). However, it is unclear as to how this influenced the sentence measures (q.3c).

The results reported earlier showed that subject B's vocal range was enhanced slightly over the course of the program. This improvement may be attributed to the wide pitch range utilised in the three songs (between 13 semitones and 19 semitones). Perhaps his vocal range was enhanced as a consequence of the frequent singing of songs with wide pitch ranges.

Increases in feelings of happiness and feelings of energy and a decrease in tension were the most notable changes to mood states as a long term consequence of treatment. When considering this in light of the moods portrayed by the songs, some hypotheses can be suggested. First, the songs conveyed the emotions of sadness, restlessness, agitation and

frustration as indicated by the predominance of minor tonality, minor intervals, static movement in the melody line and rhythmic patterns, and the thematic material conveyed in the lyrics. It might be postulated that the evocation of such emotions might increase feelings of sadness and tension in subjects, particularly if subject B may already be experiencing them (Wheeler, 1985). However, in the long term, the reverse effect occurred. Perhaps the emotions portrayed through the three songs, might have reflected the emotions experienced by Subject B. One can only assume that receiving a TBI and participating in challenging, tiring and demanding rehabilitation programs would result in the build up of feelings of tension, sadness, and perhaps fear and anger, even if subject B was not able to identify these emotions and self-report them. Although speculative, this matching of emotions, which were actively expressed by subject B's participation in the singing, might have allowed the release and expression of these emotions, thus having the positive effect of enhanced mood and decreased tension in the longer term.

#### **5.4.5 Post-treatment assessments**

At the completion of the treatment program, subject B was asked to repeat two of the exercises included in the pre-selection tasks to determine whether there were any changes in his ability to discriminate pitch and emotion in intonation. The post-treatment re-assessment indicated that subject B maintained his accuracy in pitch discrimination task (100% accuracy) and increased his accuracy in affective intonation discrimination from 60% to 70%.

To determine subject B's self-perception of changes in vocal expressive potential, he was asked to indicate how he perceived his voice at the completion of the treatment program when compared with his perception at the commencement of the program. The results indicate that subject B perceived a slight improvement in his ability to express both emphasis and emotion through his voice. These perceived improvements were not evident in the numerical data reported here. This incorrect perception of his improvements may be further evidence of his lack of insight. It is also possible that subject B felt obligated to state he had improved given that he had participated in a therapy program.

Conversely, subject B may have perceived that his voice was beginning to sound more like his pre-trauma voice – low-pitched and more monotonal. As one's voice is acutely connected with self-perception and identity, any movement in functioning that restores a sense of self is regarded as positive.

#### 5.4.6 Summary and conclusions

Results of the 15-session music therapy program showed that singing songs had a reverse effect on subject B's expressive speaking potential than what was anticipated based on previous research findings (q.1, q.4). Initially the speech pathologist reported that subject B presented with difficulties in vocally expressing a range of different emotions. This was demonstrated by his poor ability to modify the  $F_0$ , SVS and slope in order to express different emotions. Following treatment, subject B was no more able to manipulate the  $F_0$  and apply more variability in his intonation contours to express emotions as he was at the commencement of the program. The long term implications of these results suggest no change in his impaired ability to engage people in conversation, and more importantly, no change in his ability to accurately portray a range of emotions leaving him unexpressive in general conversation. However, it seems clear that subject B was recovering his pre-trauma vocal characteristics, which in effect, is considered an improvement.

The influence of vocal pitch range on the vocal parameters of the  $F_0$ , SVS and slope were inconclusive (q.3a). Subject B's VR increased only slightly with a corresponding decrease in the  $F_0$ , SVS and slope. However, some conclusions can be drawn for the relationship between mood and vocal parameters. Here, subject B's responses showed that as mood became more neutral, a corresponding decrease in the  $F_0$ , SVS and slope occurred, suggesting the flatter the affect of subject B, the flatter and more monotonal his intonation became (q.3b). The exception to this is the mood data pertaining to happy and energetic where the reverse trend emerged. However, as mentioned previously, polarities in responses and a generally reported flat affect mean that these results should be interpreted with caution.

It was noticeable that subject B improved in his pitch control as evidenced by improvements in the PME, the PMS and the overall improvement noted in the contour analyses (q.3c). However, the influence of these improvements on the speaking intonation parameters is unclear.

In conclusion, the outcome of subject B's 15-session treatment program was an enhancement of his mood and an improvement in his vocal range and control. However, his  $F_0$ , SVS and slope decreased away from the non-clinical samples. While this may be considered a reverse effect to that intended, the direction of change was consistent with his pre-trauma vocal style.



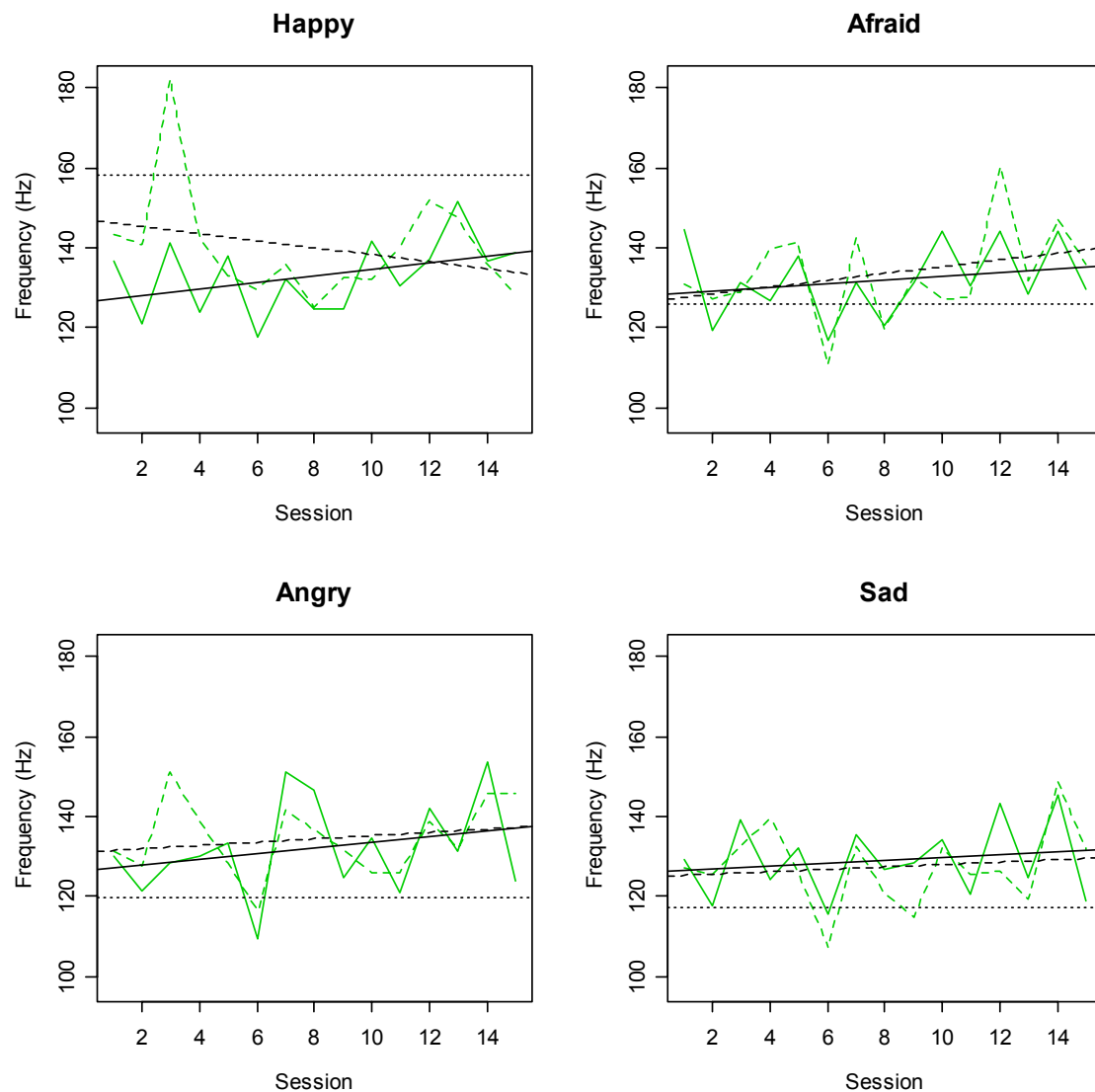
## 5.5 Subject C

### 5.5.1 Sentence measures

The following section details and discusses the responses of subject C within the sentence reproduction tasks for the parameters of the  $F_0$ , SVS and slope.

#### *Fundamental frequency*

Figure 31 shows the immediate and long term effect of treatment on the  $F_0$  measures of subject C.



**Figure 31. Subject C: Trends in fundamental frequency**

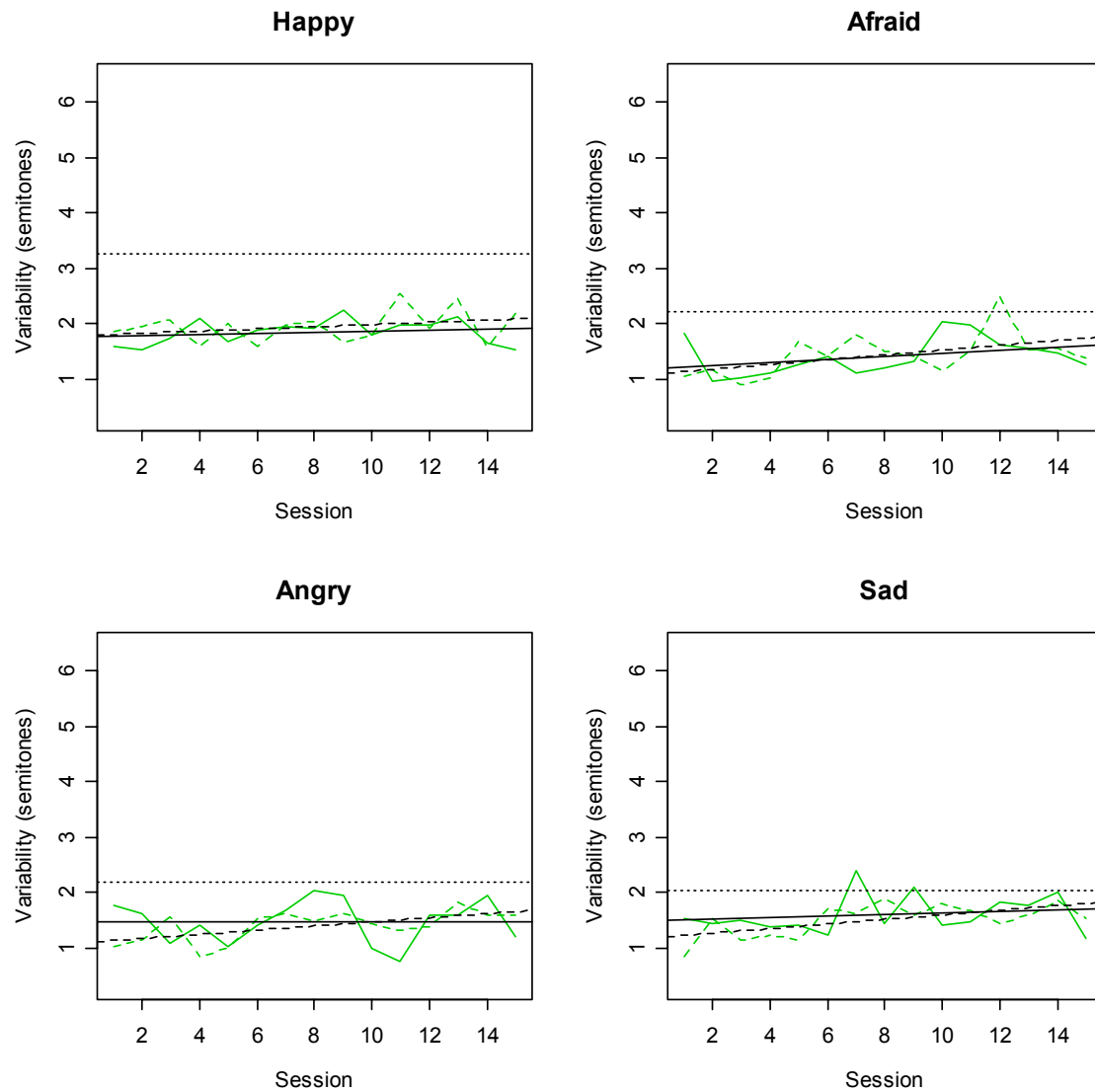
Figure 31 shows that in the long term, the  $F_0$  of sentences was raised. These increases were particularly noticeable in the sentences for angry and afraid, and less noticeable for sad. The  $F_0$  of the sentence for happy showed a tendency to increase in the post-session assessment and decrease in the pre-session assessment. This decreasing pre-session trend line was highly influenced by an outlying data point observed in session three. When listening to this audio sample, subject C tended to over-exaggerate the sentence in a similar fashion to that described for subject B.

The long term changes in  $F_0$  for the different sentences suggest that subject C made some improvement in his ability to differentiate between different mood states. Differentiation in the  $F_0$  between the sentences for happy, sad, angry and afraid, increased over time, however the differentiation between angry and afraid was marginal. This can be seen by comparing all trend lines at hypothetical session zero (each of the four sentences were spoken at a  $F_0$  of approximately 130Hz) with the trend lines at session 15 (where there were greater differences in  $F_0$  between the four affective sentences). Apart from the  $F_0$  for happy, the  $F_0$  for subject C was generally higher than the non-clinical sample even during the initial stage of treatment.

With the exception of sad, the post-session measures were lower than the pre-session measures. However, trend lines indicate that the differences between the pre- and post-session measures reduced over time in the sentences expressing happiness and anger. This suggests that subject C became more responsive to the treatment over time. For all sentences, the range of  $F_0$  measurements varied significantly throughout the program, subject C showing little consistency at any point or for any sentence.

### ***Standardised variability score***

Figure 32 illustrates the immediate and long term effect of treatment on the SVS for subject C.



**Figure 32. Subject C: Trends in standardised variability scores**

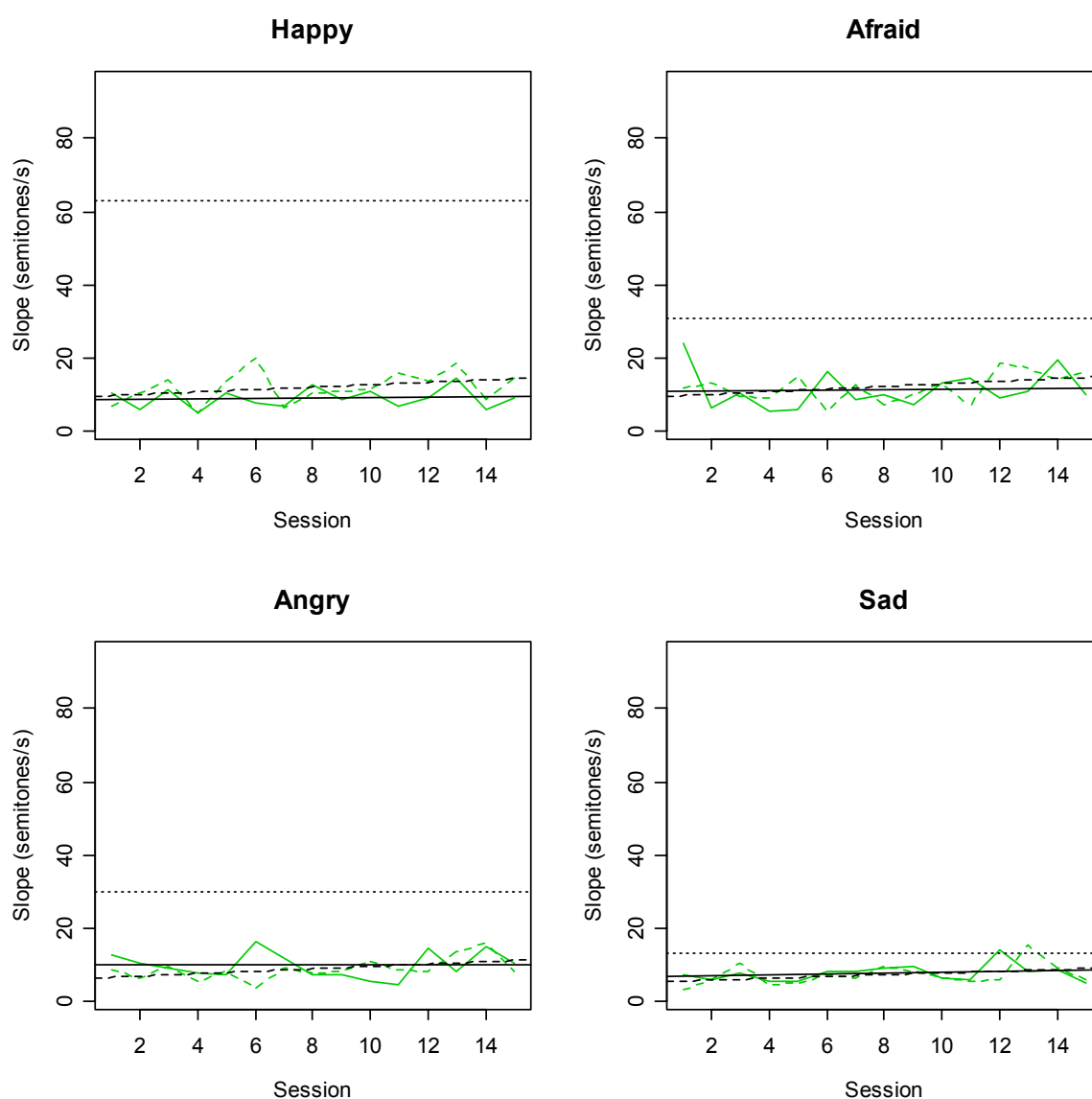
This figure illustrates the large difference in variability between the responses of subject C and that of the non-clinical sample across all four sentences. Over the course of treatment, the differences in SVS measures decreased across all four sentences between subject C and the mean for the non-clinical sample. The most substantial improvements were noted in the sentences expressing fear and sadness, with the SVS scores in the sentence for sad approaching the mean for the non-clinical sample. No improvements were evident in this figure in the ability of subject C to use differentiated SVS between the sentences, however considering the degree of impairment apparent in the communication of subject C, the increases in SVS are regarded as positive.

The immediate effects of treatment on the SVS varied between the sentences. The post-session measurements were generally higher for angry and sad, and lower for happy.

There were no immediate treatment effects on SVS for afraid. For all sentences, the trends for the immediate effects of treatment reversed towards the end of the program. The raw data of subject C lacked the patterns of high peaks and troughs seen in his  $F_0$  data. This suggests that subject C utilised a more consistent level of SVS when verbally communicating.

### *Slope*

Figure 33 illustrates the immediate and long term effects of treatment on subject C's production of slope for the four sentences.



**Figure 33. Subject C: Trends in slope measures**

This figure shows that at the commencement of treatment, subject C demonstrated substantially lower measures of slope for all sentences, particularly for happy, when compared with the non-clinical sample. However, the differences in slope between subject C and the non-clinical sample decreased over time suggesting the treatment had a positive effect on the ability of subject C to bring about faster and greater changes of pitch while speaking. The degree of increase in slope was similar across all four sentences. Despite these improvements, subject C did not increase his ability to use varying levels of slope to depict different mood states and he consequentially remained substantially impaired in this area when compared with the non-clinical sample.

Generally, the immediate effects of treatment were minimal. It was observed that a small post-session increase in slope was noted for angry, this difference being non-existent by the conclusion of the program. There were no apparent immediate treatment effects displayed for the sentence expressing sadness. An immediate treatment effect in the direction opposite to that suggested by previous research literature was noted in the slope for the sentences expressing happiness and fear, the post-session slopes being generally less steep than those in the pre-session.

### ***Discussion of sentence measures***

Prior to commencing the study, the speech pathologist reported that subject C presented with a lower  $F_0$ , that his use of pitch in speech was limited, and that he displayed a severe impairment in creating expressive intonation patterns. The family of subject C concurs with the assessment reported by the speech pathologist stating that, post-injury, subject C spoke with a more monotonal vocal style and a lower vocal pitch. The data analysed from the initial sessions of the program confirm that subject C spoke with a flat and monotonal style, predisposing him to being at risk of not engaging a listener in conversation, and also at risk of his emotional state being misunderstood. However, the data also showed that the  $F_0$  of subject C was slightly higher than that of the non-clinical sample and appropriate for his age group (Colton & Casper, 1996). Therefore, there are some inconsistencies in opinion between what is considered an appropriate level of  $F_0$  for subject C, given the conflicting measures between the speech pathology report, family report, mean  $F_0$  for the non-clinical sample, and the  $F_0$  measures typical of males in this age group as determined by prior research.

The increases in the  $F_0$ , SVS and slope that occurred over the course of treatment suggest that the treatment had a positive effect on the potential for subject C to express

emotion (q.1). The continuing upward trends noted at the end of the program suggest that ongoing therapy would be beneficial in further developing the expressive potential of subject C.

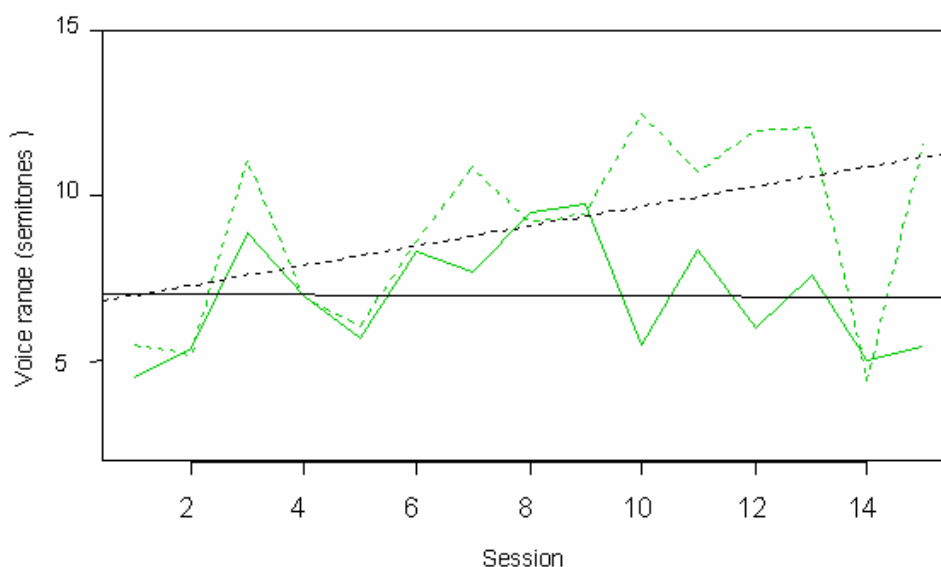
There are several possible explanations for subject C's improvements. First, subject C may have experienced a decrease in vocal fold tension, allowing him more vocal freedom and greater potential for applying larger SVS and steeper slopes (Leonard et al., 1988). The flaw in this argument is that one would expect a corresponding decrease in  $F_0$  to also occur, and observations suggest that this was not the case. An increase in affect or in levels of energy might also underpin such changes in vocal fold behaviour (Aronson, 1990; Bunch, 1997; Pittman, 1994; Stengel & Strauch, 2000) and will be discussed together with the results from the VAMS (5.5.3).

The immediate responses to treatment of subject C varied between the three intonation measures and between the four sentences (q.1). However, there was a frequently occurring trend of a positive immediate response to treatment as evidenced by the post-session measures being higher than the pre-session measures (refer to SVS and slope measures for angry and sad). This trend did not emerge in the  $F_0$  data. The trend lines for  $F_0$  are not as reliable as those for SVS and slope due to the higher degree of variability in responses that emerged in the  $F_0$  raw data.

In conclusion, the responses produced by subject C show that his treatment had a valuable effect on his potential for enhanced expressivity. Due to the continued improvement noted towards the end of the program, further treatment is recommended here so that subject C would become better able to differentiate between the different emotions.

### **5.5.2 Vocal range**

The next section reports and discusses changes in the VR of subject C and how these changes relate to changes in his intonation measures. Figure 34 illustrates the immediate and long term changes in the VR of subject C.



**Figure 34. Subject C: Trends in vocal range**

Figure 34 shows that VR measurements taken at the pre-session increased over the course of treatment (q.2a). Initially, subject C was only able to produce a range of approximately five semitones, but this increased to as many as 13 (session ten). The VR measurements of subject C post-session were almost always less than those collected pre-session, suggesting that treatment had an immediate reverse effect of reducing his range. Fatigue at the post-session might explain this decrease in VR (Oddy et al., 1985; Prigatano, 1999b). The raw data points show that there was a noticeable dip in the VR of subject C at session 14 (particularly in the pre-session data).

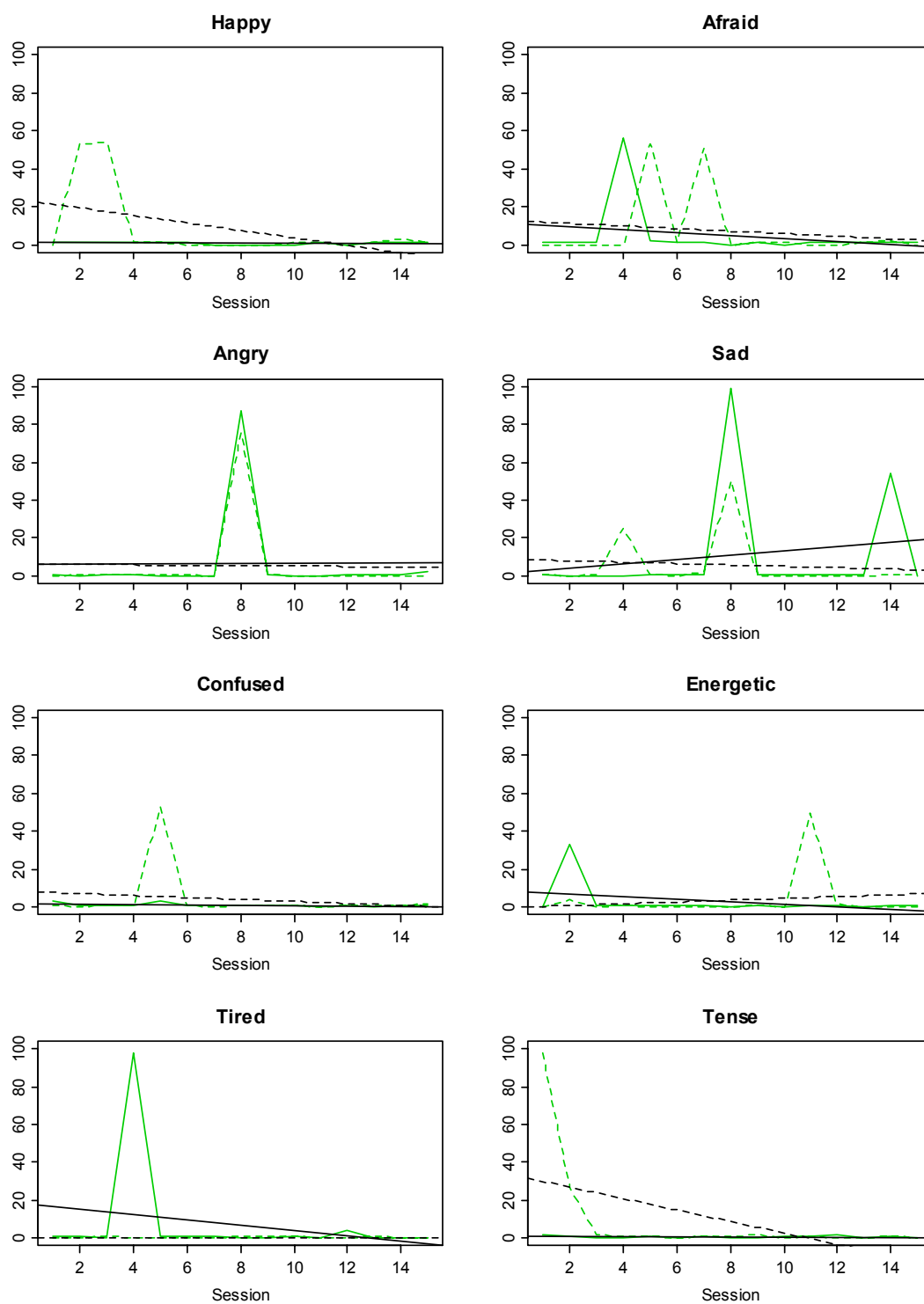
Although there was a steady long term increase in the VR at the pre-session, there are large variations in the responses from session to session. Such peaks and troughs were also evident in the  $F_0$  data. As suggested for subject B, such variability could have arisen from fluctuating states of motivation (Bowen et al., 1998; Prigatano, 1999a), fluctuating physical tension and levels of fatigue (Leonard et al., 1988) and mood changes (Prigatano, 1999a).

### ***Discussion of vocal range and sentence measures***

The results show that the VR of subject C increased over the course of the program, although this was only evident pre-session (q.2a). These increases paralleled those observed in the  $F_0$ , SVS, and slope data, suggesting a relationship exist between these measures (q.3a). This suggests that the participation by subject C in the treatment program facilitated an increased VR, therein enhancing overall vocal expressive potential.

### 5.5.3 Visual analog mood scale

The next section reports and discusses the immediate and long term effects of treatment on the mood of subject C, and relates these to changes in intonation. Figure 35 displays the mood changes reported by subject C from pre- to post-session, and over time.



Key: x-axis = session number, y-axis = VAMS score (out of 100).

**Figure 35. Subject C: Trends in visual analog mood scale scores**



Subject C did not report feeling any one particular mood state on a frequent basis. Generally, he reported a flat affect as indicated by the frequency of zero scoring. However, when he did experience a mood, subject C reported this experience as intense (scoring very high on the scale). It is noticeable that subject C reported strong feelings of sadness and anger during session eight (at both pre- and post-session). Session four was also atypical, characterised by a reported increase in fatigue and fear at the post-session. It is possible that during these sessions, subject C experienced a raised level of awareness and insight into his own perceived feelings and subsequently reported experiencing these emotions at a more heightened level when compared with his responses during other sessions.

The high frequency of zero scoring in this task precludes conclusions being drawn regarding the immediate and long term effects of treatment on the mood-state of subject C.

### ***Discussion of mood and sentence measures***

Because subject C generally reported a flat affect both pre- and post-session and over time, it was not possible to reliably construe what effect treatment had on mood. In the same way as suggested for subject B, it is possible that subject C lacked insight or had difficulty identifying and measuring his own mood, thus resulting in his reported flat affect (Oddy et al., 1985; Prigatano, 1999b; Prigatano & Schacter, 1991).

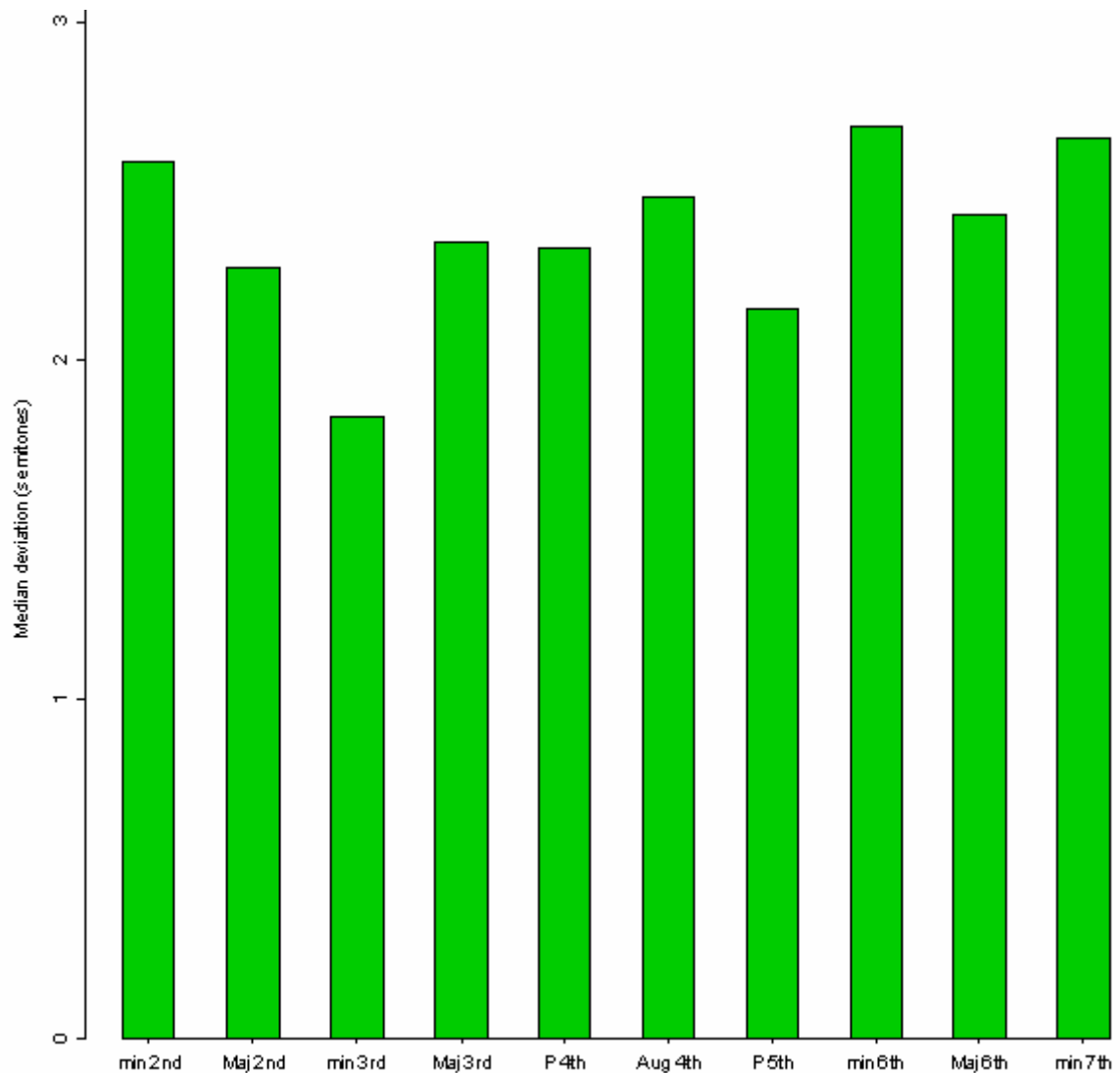
Due to the limited number of occasions subject C reported experiencing a mood, it was not possible to establish any connection between mood and the three sentence measures (q.3b). Sessions four and eight were identified as sessions where extreme mood changes were reported. When the data from these sessions were compared with the pre- and post measures for  $F_0$ , SVS, and slope, there were no corresponding extreme peaks or troughs evident to support any possible connection between them.

### **5.5.4 Pitch matching in exercises and songs**

The following section reports and discusses the findings regarding the ability of subject C to sing intervals within PME and within song phrases (PMS). This section follows the same format as that detailed for subject B (5.4.4).

#### ***Pitch Matching Exercises***

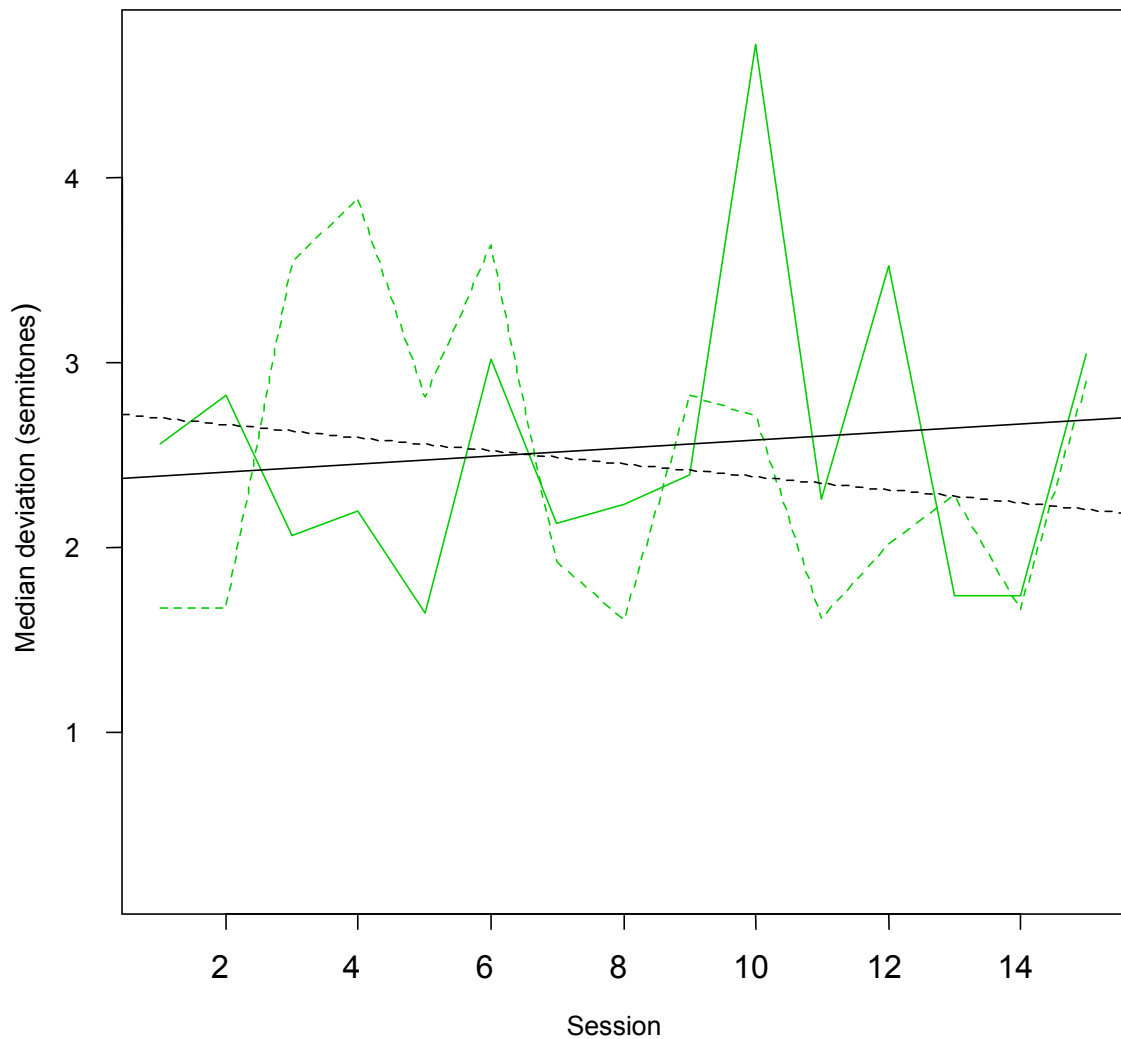
Figure 36 illustrates how subject C varied in his accuracy of reproduction across different intervals. Here, the y-axis reports the median number of semitones subject C deviated above or below the target reproduction of each interval.



**Figure 36. Subject C: Differences between intervals in pitch matching exercises**

This figure illustrates that overall, subject C was highly inaccurate in reproducing intervals. Generally he was more accurate in his production of the smaller intervals (with the exception of the minor 2<sup>nd</sup>) and less accurate on the larger and more difficult intervals. The minor 3<sup>rd</sup> and perfect 5<sup>th</sup> were the intervals most accurately reproduced whereas the minor 6<sup>th</sup> and minor 7<sup>th</sup> were the least accurate.

Figure 37 below details the immediate and long term changes in pitch matching accuracy when the data from all the intervals were pooled. Again, the y-axis reports the median number of semitones subject C was away from accurate interval reproductions.



**Figure 37. Subject C: Trends in pitch matching exercise**

Figure 37 shows that there is no overall improvement in the ability of subject C to match intervals, with the pre-session trend line indicating overall improvement in accuracy and the post-session trend line showing the reverse trend (q.2c). Such trends have been significantly influenced by the frequency of extreme values and therefore these trend lines should be interpreted with caution.

The high variability in responses is likely to be a result of the significant cognitive problems (poor impulse control, perseveration, poor concentration and poor pitch discrimination skills) displayed by subject C. When processing the audio data, it was noted that he frequently:

- sang the interval in an upward rather than downward direction and vice versa to what was required (poor concentration or poor ability to discriminate higher from lower tones)


- began to sing the interval prior to hearing it in its completion (poor impulse control)
- sang the same interval throughout the task rather than the one presented (perseveration).
- commenced on the same note as the previous interval (perseveration)

Problems with perseveration, impulse control and poor concentration are typical of people with TBI (Prigatano, 1999a).

### ***Pitch Matching in songs***

The three songs selected by the music therapist treating subject C were chosen from a limited list of subject-preferred songs as given by the subject and his family:

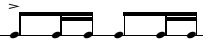
- *Heavy heart* by artist You Am I.
- *You're the voice* by artist John Farnham
- *Waltzing Matilda*, a traditional Australian song

*Heavy heart* is a three-verse song with no chorus but a common final lyric for each stanza *Now I've got a heavy heart*. The song focuses on a loss of a relationship and its consequential effects on a man's life. A feeling of sadness and longing prevail throughout. The range of the song is limited to a major 6<sup>th</sup> with the largest interval being that of a perfect 4<sup>th</sup>. Most of the melodic movement is stepwise. The song is embedded in C major, but the frequent use of this downward melodic line  creates a minor feel. The harmonic movement is rich, moving through two predominant chordal sequences:

- a) C major, E major, F major, F minor A<sup>b</sup> major and
- b) B<sup>b</sup> major, F major, F major and A minor.

Despite the overall slow tempo of the song, a repeated quaver rhythm characterises the melody line. The overall mood of this song fits into the description of sadness as described in Table 11.

The text of *You're the voice* contains a strong message about people coming together and standing up for what they believe in. The song contains two verses and three choruses and demands a high level vocal skill to sing it competently. The song typically contains long sustained *ah* sounds, which move up and down in scale-like patterns, this being difficult, even for an amateur singer. The melodic range is wide (a minor 10<sup>th</sup>, 15 semitones) and high in pitch register (A<sup>3</sup> to C<sup>5</sup>). The melodic line moves constantly with the perfect 4<sup>th</sup> a regularly occurring interval. The largest interval within the melodic line is

the major 6<sup>th</sup>. Harmonically, this song contains simple, predictable and strong chordal progressions utilizing the chords of F major, E<sup>b</sup> major, B<sup>b</sup> major and G minor. The tempo is fast and lively featuring  as the central rhythmic pattern. Overall, this song creates a happy, dignified and majestic mood.

Of the aforementioned three songs, *Waltzing Matilda* was selected as the song to be used for analysis. *Waltzing Matilda*, a traditional Australian folk song, is arguably the most well known Australian song. This song was selected because the key phrase in the song (Figure 38) contained the largest pitch range (an octave) when compared with the two other songs employed in the program. The key phrases in the other two songs contained a pitch range of a perfect 5<sup>th</sup> (*You're the voice*) and a major 3<sup>rd</sup> (*My heavy heart*).

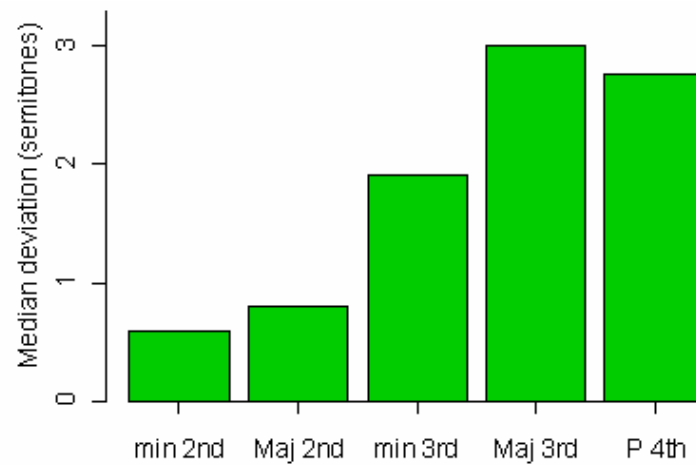
The melody of *Waltzing Matilda* contains a balance of stepwise motion and large interval jumps (the largest being a minor 6<sup>th</sup>) with a total range of a major 11<sup>th</sup>. The song contains four verses and a repeated chorus. The text is about the story of a swagman, based on the poetry of Banjo Patterson, a famous Australian poet. The genre of the song is *Australian Bush* style with a driving tempo (common time) and utilising simple and predictable harmonic changes. The song is typically sung with energy and vigor and was often used in *Australian bush dances*.

The key phrase selected for analysis *You'll come a waltzing matilda with me* extends over an octave and contains seven intervals (excluding the unison) - three major 2<sup>nds</sup>, a minor 2<sup>nd</sup>, a minor 3<sup>rd</sup>, a major 3<sup>rd</sup>, and a perfect 4<sup>th</sup>. Figure 38 illustrates the melodic line of the key phrase.



**Figure 38. Selected song phrases for analysis**

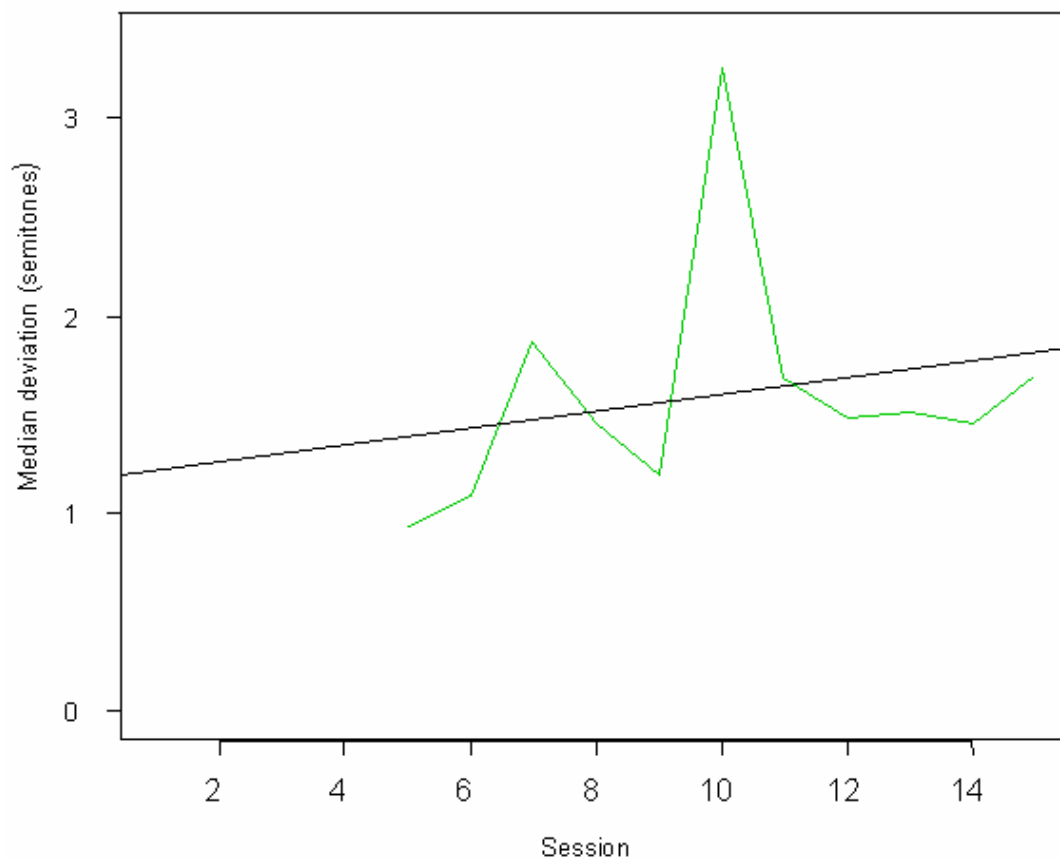
Figure 39 illustrates the degree of singing accuracy by subject C in his singing of the five different intervals. As in the PME, the y-axis reports the median number of semitones subject C was away from accurate interval reproduction.



**Figure 39. Subject C: Differences between intervals in song phrases**

Figure 39 illustrates that the minor 2<sup>nd</sup> was the most accurately sung interval and that the major 3<sup>rd</sup> was the most difficult to sing within the context of a song.

Figure 40 details the immediate and long term changes in singing accuracy of intervals contained in song phrases when the data from all the intervals were pooled. As before, the y-axis reports the median number of semitones deviated from the target.



**Figure 40. Subject C: Trends in pitch matching in songs**

Figure 40 explicates that there was a decrease in the accuracy of interval production over time. This trend parallels the decreasing accuracy also observed in the PME. As mentioned previously, boredom, poor impulse control and poor concentration skills could explain why subject C was not able to sing more accurately over time (Prigatano, 1999a). It is noticeable that in session ten, subject C displayed substantially poorer accuracy when compared with all other sessions. This was also the case in the PME post-session (Figure 37). No other unusually large peaks or troughs in other data were evident in session ten.

### ***Analysis of song contours***

This section documents the results of the contour analysis for the song phrase *You'll come a waltzing matilda with me* sung during three sessions (sessions five, nine and 14). Session one could not be analysed as the song material from this session was corrupted. Figure 41 illustrates the sung responses of subject C during the three sessions. The first contour (top) is that sung by the music therapist who gives the most accurate reproduction of the phrase.

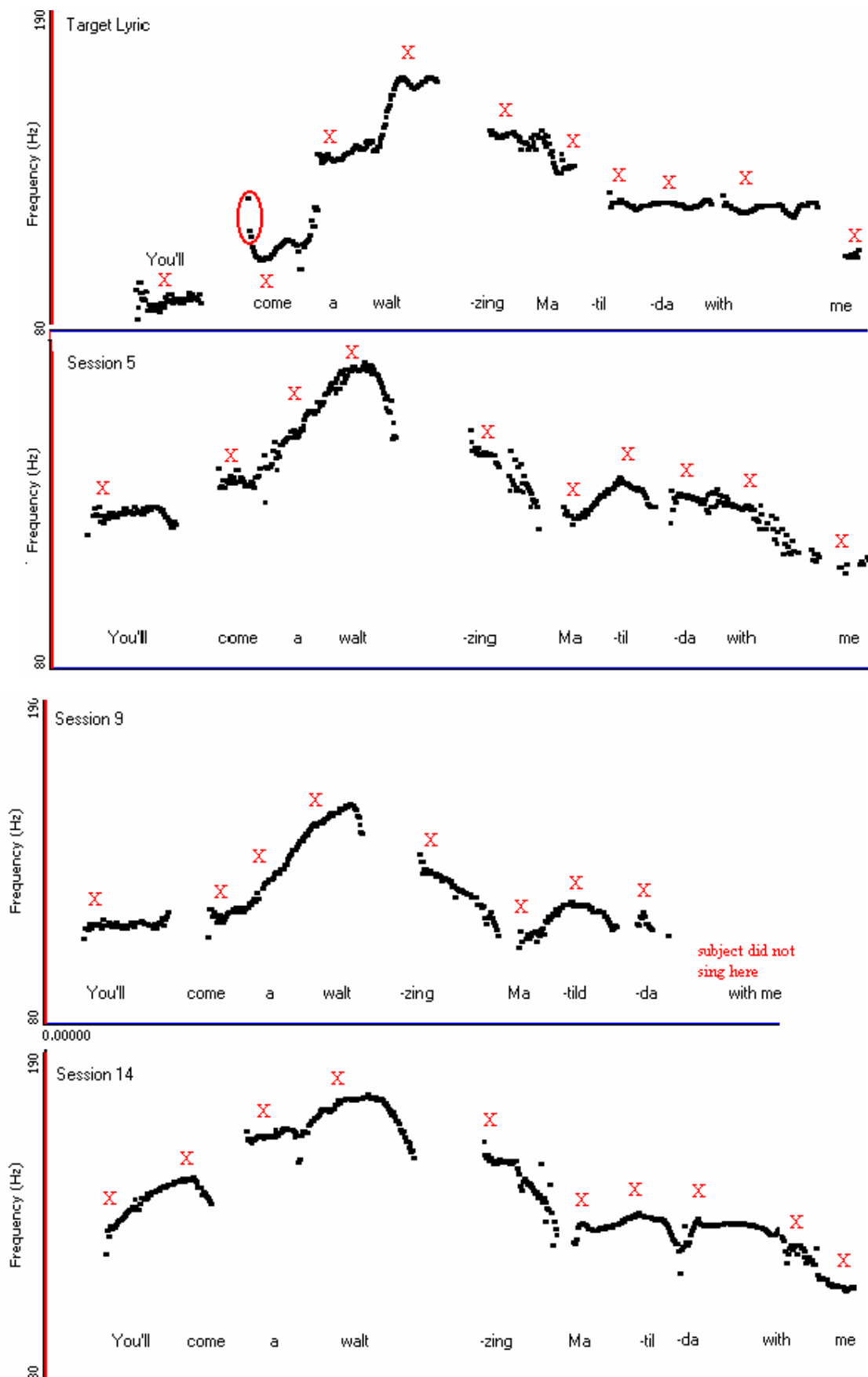


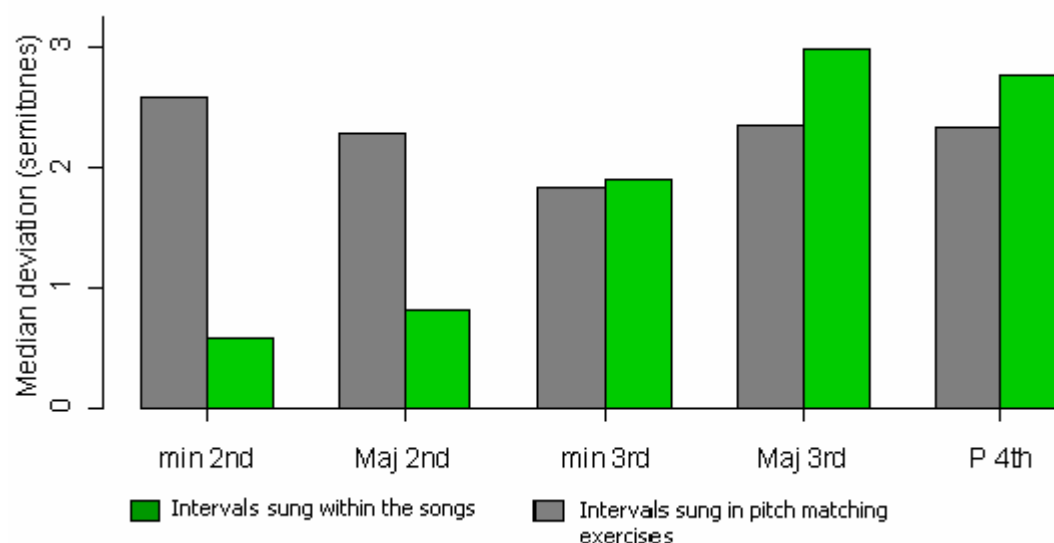
Figure 41. Subject C: Contours for selected song phrase



Figure 41 illustrates the redevelopment of pitch control in subject C over the course of treatment. During session five and session nine subject C displayed reasonably accurate singing when compared with the target (q.2c). However, session 14 highlights how subject C became more controlled in sustaining pitch as is evident in his performance of the repeated tone in the syllables *til-da with*, which were controlled when sustained. This skill in pitch control was not seen in the earlier sessions. Figure 41 also shows that during the earlier sessions, subject C used a vocal sliding technique to move from one pitch to the next. During session 14, subject C displayed how he was more able to quickly and clearly shift from one pitch to another without the need to slide. The development of pitch control evident in these contours was not observed in the numerical data presented earlier.

### ***Comparison between pitch matching exercises and pitch matching in songs***

Figure 42 compares the five intervals contained within the PMS with the same five intervals produced in the PME.



**Figure 42. Subject C: Accuracy differences between pitch matching exercise and pitch matching in songs**

When a comparison was made between the intervals sung in the PME and PMS, it was found that subject C was more able to sing the smaller intervals (minor 2<sup>nd</sup> and major 2<sup>nd</sup>) more accurately when they were placed within the context of a song. The opposite finding was apparent for the medium sized intervals (major 3<sup>rd</sup> and perfect 4<sup>th</sup>) whereby the intervals were produced somewhat more accurately when presented in the PME. There were no large intervals present in the song phrases, so these results should be interpreted

with caution. Given that the accuracy in singing intervals was higher in the PMS (Figure 40) when compared to the PME (Figure 37) it would appear that for subject C, song singing provided a frame for a more accurate assessment of his vocal pitch control.

### ***Discussion of pitch matching in exercises, songs and other measures***

It is difficult to determine with certainty whether singing songs had a positive effect on pitch control for subject C, given the conflicting findings between the numerical data from the PME and PMS, and the contour data (q.2c). What was evident was the interference of cognitive impairments (poor impulse control and perseveration) in carrying out the PME.

Increases in the  $F_0$ , SVS and slope were evident for subject C and corresponded with improvements in pitch control (as portrayed in the contours). However, no improvements in accuracy were evident in the PME and PMS and therefore no relationship between pitch control and the sentence data can be proposed (q.3c).

Earlier, it was reported that the VR of subject C increased from five semitones to a maximum of approximately 13 semitones over the course of treatment. As the melody line in two of the three songs ranged between 15 and 19 semitones, his engagement in the singing of these songs may have facilitated this large increase in VR. Natural recovery cannot be ruled out as a possible contributing factor in his improvement.

As subject C reported a flat affect throughout the treatment program (with the exception of sessions four and eight), it was not possible to reliably link the musical elements of the songs with immediate or long term changes to mood states.

### **5.5.5 Post-treatment assessment of pitch and intonation discrimination**

At the completion of the treatment program, subject C repeated two of the exercises included in the pre-selection tasks to establish whether he improved in his pitch ability to discriminate pitch and affective intonation. The post-treatment re-assessment indicated that subject C decreased his accuracy in pitch discrimination from 80% to 60%. In contrast, intonation discrimination improved from 20% to 50% post-treatment. This suggests that subject C became more able to accurately perceive the emotions portrayed in speech. It is possible that fluctuations in the concentration and attention of subject C might be factors contributing to both the increases and decreases noted in these tasks at the post-treatment assessment.

To determine whether subject C perceived a change in his vocal expressive potential, he was asked to indicate his perceptions on a post-therapy questionnaire. Subject C reported that he could not perceive any change in his voice, or any change in his ability to express emotion or emphasis in his voice.

### 5.5.6 Summary and conclusions

The results of the 15-session music therapy program showed that singing songs had a positive effect on the expressive speaking potential of subject C (q.1). Initially, he displayed difficulty manipulating the  $F_0$ , SVS and slope to create intonation contours representative of different emotions. Following treatment, subject C was utilising higher SVS and steeper slopes in his speaking voice. This suggests that he became less monotonal and more vocally expressive. Despite these improvements, the speaking voice of subject C remains well below the level of variability typical for a man of his age as informed by the mean SVS of the non-clinical sample (q.4).

Across the three intonation measures and across all four sentences analysed, trends in treatment effects varied. Immediate changes (pre/post-session) were generally small, and in some cases were positive and in other cases negative. No noticeable patterns were evident here. Overall, long term improvements were noted across all intonation measures.

It was noticeable that the VR of subject C increased over the course of the program and this may suggest a direct relationship with the increases in the three speaking intonation measures (q.3a). No attempt was made to link changes in speaking intonation with mood as subject C generally reported a flat affect, this being typical of TBI (Prigatano, 1999b) (q.3b).

Improvements in interval reproduction regardless of context were not evident and therefore no link between this and the noted improvements in sentence intonation measures were established (q.3c). It is important to mention here however, that significantly impaired cognition displayed by subject C, particularly poor concentration, poor impulse control and perseverative tendencies, were likely to have influenced his responses within these tasks – particularly within the PME.

In conclusion, subject C was responsive to the singing program as evidenced by improvements made in the three intonation measures over the course of treatment. Trends suggest that as improvements continued throughout the program, continued treatment may have further enhanced the expressive speaking potential of subject C.

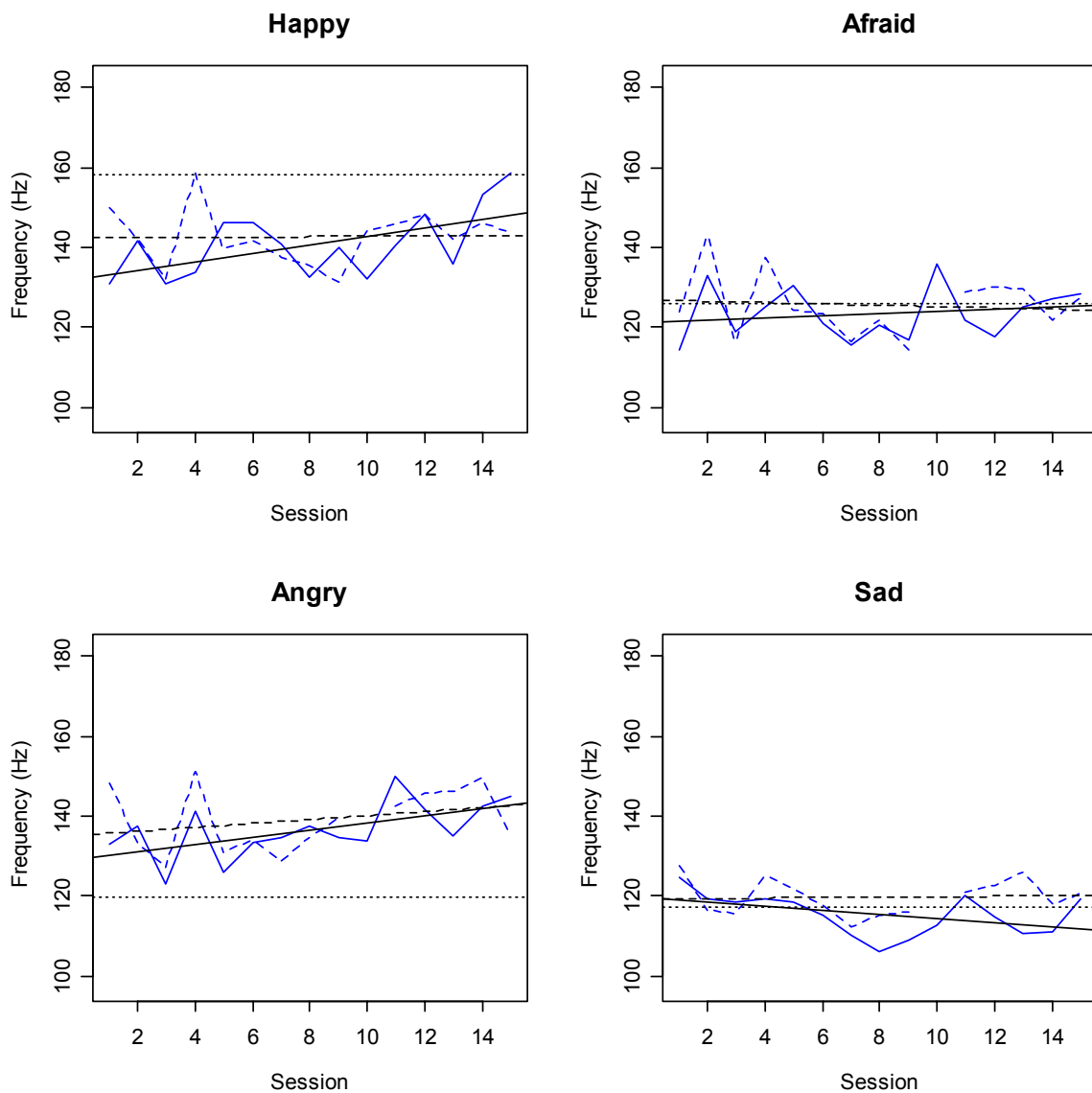
## 5.6 Subject D

### 5.6.1 Sentence Material

The following section details and discusses the responses of subject D within the sentence reproduction tasks for the parameters of the  $F_0$ , SVS and slope.

#### *Fundamental frequency*

Figure 43 illustrates the immediate and long term effect of treatment on the  $F_0$  of subject D.



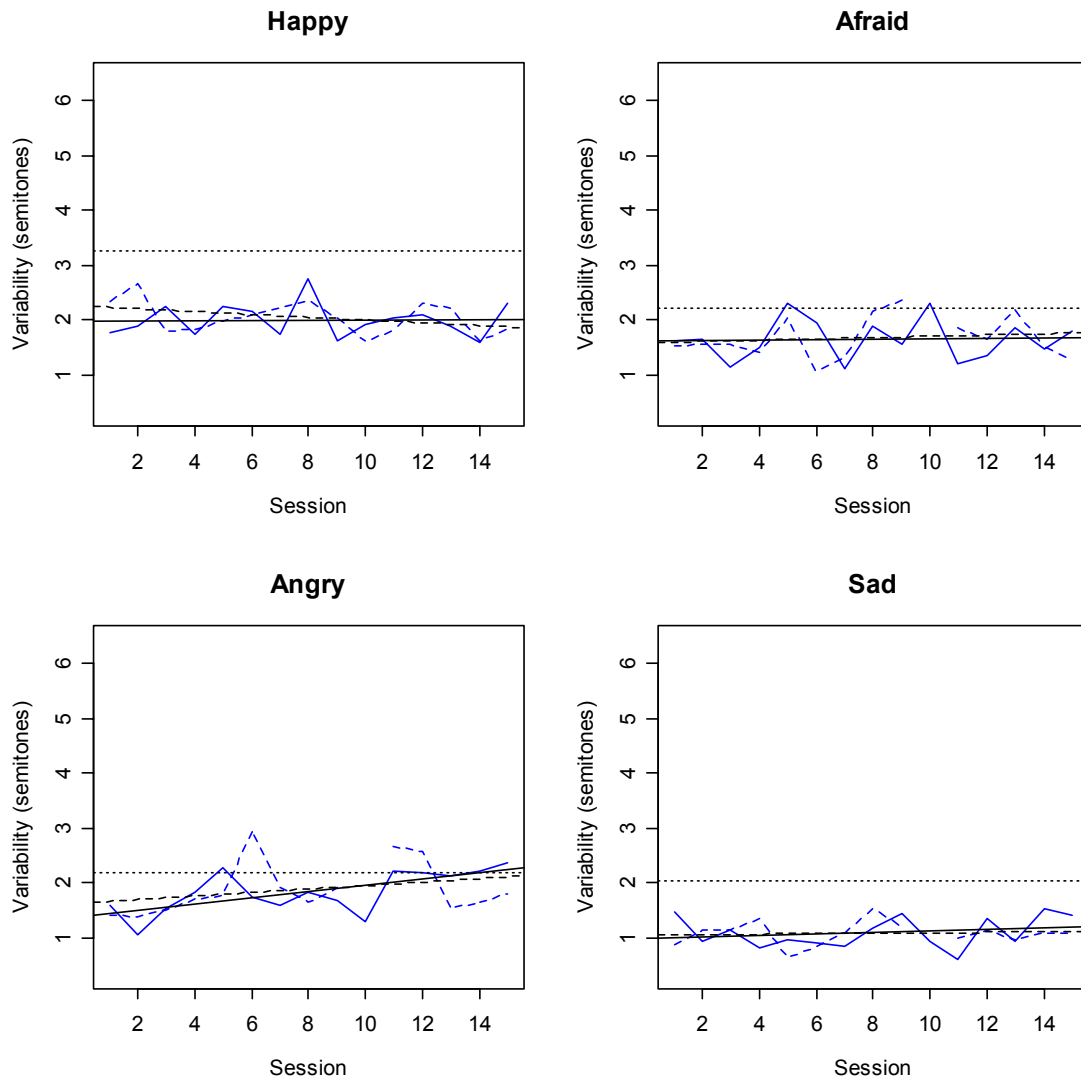
**Figure 43. Subject D: Trends in fundamental frequency**

The  $F_0$  produced by subject D in the sentences expressing happiness, anger and fear were raised over time, particularly for happy and angry, but became lower for sad. As inflecting sadness involves a lowering of the  $F_0$ , this result is regarded as appropriate. The  $F_0$  trend lines representing the responses given in expressing happiness, moved towards the non-clinical sample. The  $F_0$  produced in expressing anger was also raised over time, despite the initial  $F_0$  produced being higher than that of the non-clinical sample. The  $F_0$  produced in the sentence expressing sadness and fear were already at levels approximating those of the non-clinical sample. The most important finding here is that the  $F_0$  produced for each affective sentence became more differentiated from the others over time, suggesting an improvement in the ability of subject D to express different emotions sensitively and more appropriately.

Generally, the  $F_0$  responses generated by subject D were lower at the post-session than at the pre-session. In some cases, the trend lines show that, over time, post-session data measurements approached those of the pre-session measurements (angry, afraid), and in other cases, the post-session data measurements became higher (happy) than those produced in the pre-session tasks.

### ***Standardised variability score***

Figure 44 illustrates the immediate and long term changes in the ability of subject D to manipulate SVS in order to express four different emotions.



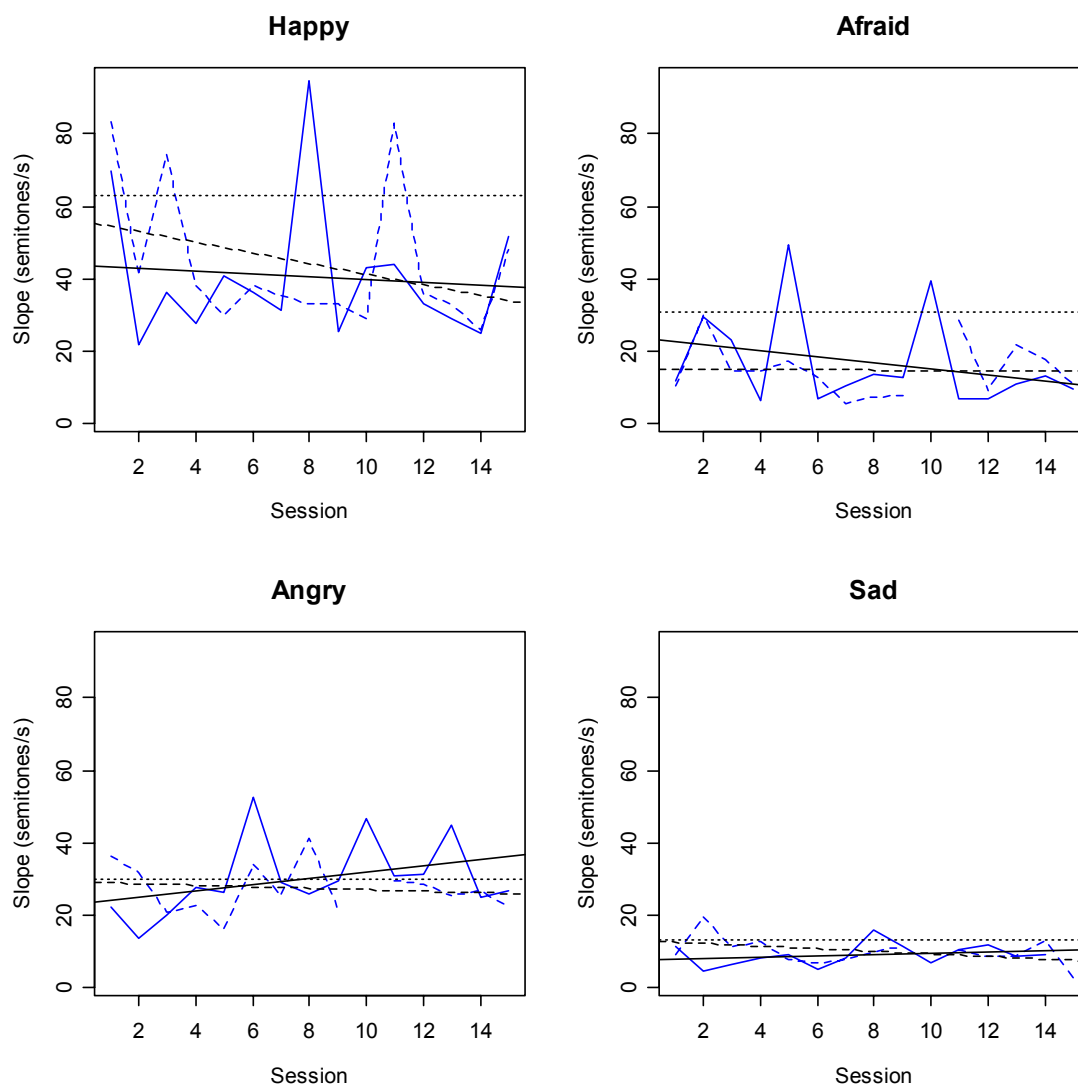
**Figure 44. Subject D: Trends in standardised variability scores**

This figure illustrates that subject D developed greater levels of speaking variability (SVS) and therefore reduced monotonal speaking patterns over time, across all four sentences. The largest increases in SVS were noted for the production of sentences expressing anger, where the trend line increased to levels similar to the mean of the non-clinical sample by the conclusion of treatment. Despite these increases, the SVS for the sentences expressing happiness, sadness and fear remained well below the mean SVS levels of the non-clinical samples throughout his treatment. Further, there was no noticeable change in the ability of subject D to apply differentiated SVS levels to express different emotions. The exception to this is for the expression of anger where the SVS used to express anger became more differentiated from that employed to express the other three emotions. The SVS trend lines illustrate that post-session response measures were lower

than the pre-session measures early in the treatment with this trend reversing towards the end of the treatment.

### *Slope*

Figure 45 illustrates the immediate and long term changes in the ability of subject D to manipulate slope in order to express four different emotions.



**Figure 45. Subject D: Trends in slope measures**

Here immediate and long term changes in the levels of slope produced by subject D differed for each sentence. The degree of slope in the sentences expressing happiness and fear fell over time, increased for anger, and remained unchanged for sad. Generally, the level of slope spoken by subject D when expressing anger and sadness approximated that

of the non-clinical sample, however, the trend line for the sentences communicating fear and happiness remained below those produced by the non-clinical sample. Here it is also noticeable that responses were highly variable, particularly post-session, and consequently, the trend lines should be interpreted with caution. Variability in response was highest when subject D attempted to communicate happiness, and lowest when he attempted to communicate sadness. The degree of slope produced was higher in the pre-session during the initial phase of treatment (in all cases except for afraid), but there was a reversal in this trend towards the latter part of the program whereby the degree of slope produced post-session became larger than the pre-session slope. This same trend was evident in the  $F_0$  and SVS data.

### ***Discussion sentence measures***

Prior to commencing the study, subject D had difficulty in manipulating the  $F_0$ , SVS and slope to create intonation contours representative of different emotions. His  $F_0$  was typically lower than the non-clinical sample, his contours were typically monotonal and his slope in most cases lower than the non-clinical sample. Subject D was unexpressive in general conversation and at risk of his emotional state being misunderstood. In general, results show that the  $F_0$  and SVS produced by subject D increased over the course of treatment, indicative of a higher-pitched and less monotonal speaking style (q.1, q.4). Such outcomes suggest he had acquired a greater expressive potential for more effective emotional expression. Furthermore, subject D was found to have made long term improvements in his ability to differentiate between the different emotions through his manipulation of  $F_0$ , but not through his manipulation of SVS and slope. This would signify a partial improvement in his ability to portray emotions through his voice. Given that subject D remained somewhat impaired in his use of SVS when compared with the non-clinical sample, continued treatment in this area is recommended to further enhance his communication.

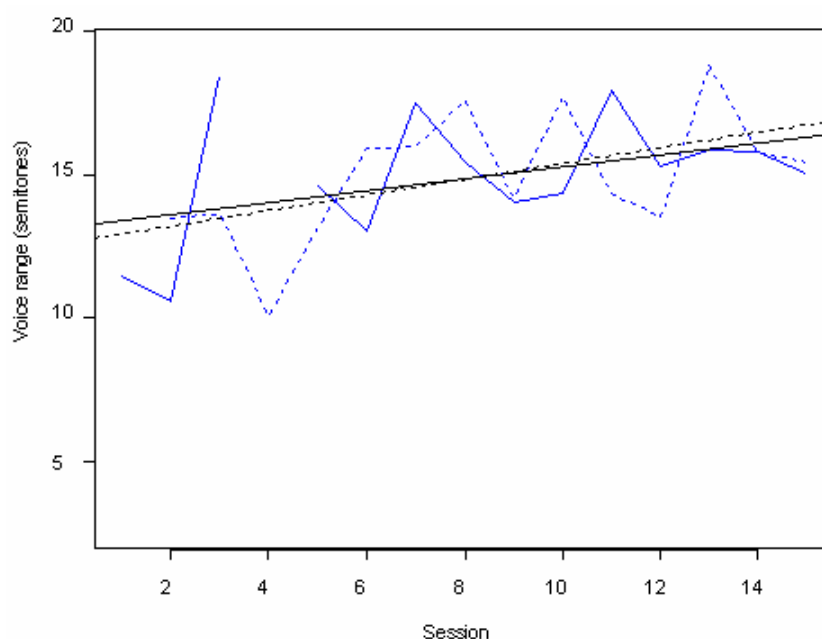
As was reported for subject B and C, subject D displayed immediate effects of the treatment in the direction reverse to that suggested by the literature. In all cases except for afraid, the  $F_0$  was higher, the SVS was wider, and the slope was steeper at the pre-session when compared with the post-session. This was particularly apparent during the initial stages of treatment. Explanations for this outcome could include post-session fatigue resulting in a poorer performance overall (Aronson, 1990; Bunch, 1997; Pittman, 1994;



Stengel & Strauch, 2000). However, there was a shift in this trend towards the middle of the program suggesting the effects of treatment were cumulative.

### 5.6.2 Vocal range

The next section reports and discusses changes in the VR of subject D and how these changes relate to changes in his intonation measures. Figure 46 illustrates the immediate and long term changes in the VR of subject D.



**Figure 46. Subject D: Trends in vocal range**

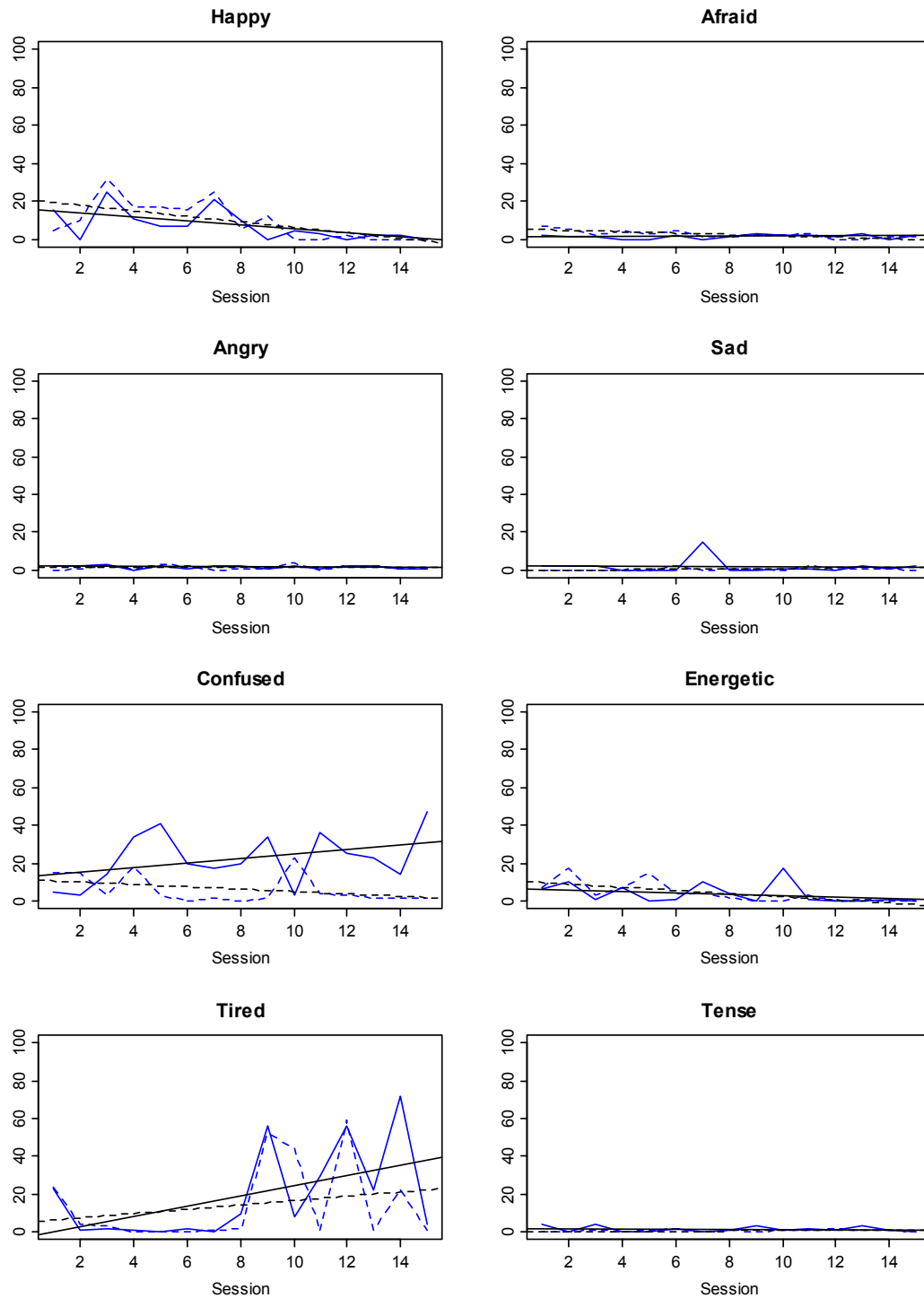
This figure illustrates the long term increases in vocal range achieved by subject D (q.2a). The immediate effects of treatment were minimal. Initially his post-session VR was higher than at the pre-session, with a reversal of this trend occurring later in the treatment. However, the trends in the immediate effects of treatment should be interpreted with caution given the high variability in responses.

#### *Discussion of vocal range and sentence measures*

As was evident for subject C, the long term data show that as the VR of subject D increased, his  $F_0$  and SVS scores also increased (q.3a). This suggests that singing songs enabled subject D to extend his vocal range and in doing so, enhanced his vocal flexibility and expressive speaking potential.

### 5.6.3 Visual analog mood scale

The next section reports and discusses the immediate and long term effects of treatment on the mood of subject D and relates these to changes in intonation. Figure 47 displays the mood changes reported by subject D from pre- to post-session and over time.



**Key:** x-axis = session number, y-axis = VAMS score (out of 100).

**Figure 47. Subject D: Trends in visual analog mood scale scores**

Figure 47 illustrates that the mood states reported by subject D were characterised by a flat affect (q.2b). The exceptions were for the mood scales of *tired* and *confusion*. Overall, the self-report measures on tiredness increased throughout the program and were higher at the post-session than at the pre-session. Self-report measures on confusion increased at the post-session and increased over time. By scanning across the eight mood scales, no particular sessions appeared to reveal strong emotional changes from pre- to post-session.

### ***Discussion of mood and sentence measures***

Because subject D generally reported a flat affect both pre- and post-session and over time, it was not possible to establish what effect treatment had on mood (q.3b). As a direct symptom of his brain injury, it is possible that subject D lacked insight or had difficulty identifying and measuring his own mood, this resulting in his reported flat affect (Oddy et al., 1985; Prigatano, 1999b; Prigatano & Schacter, 1991). It is possible that because tiredness relates to a physical state, it may have been more concrete and more easily self-perceived than the other mood states reported. This might explain why he was able to report more sensitively on this scale. Further, fatigue is a typical sequela of TBI and would be an appropriate feeling state to report post-session given that subject D had just actively participated in a therapy program that required concentration and effort (Oddy et al., 1985; Prigatano, 1999b).

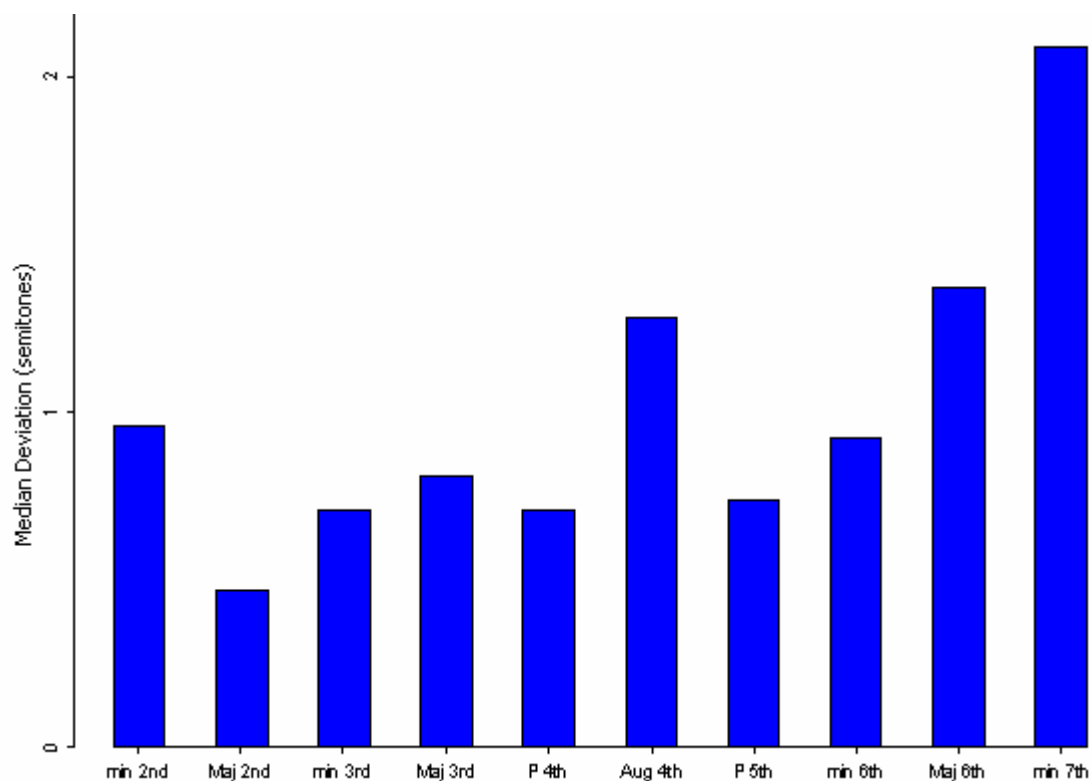
Increases in post-session fatigue reported by subject D may explain why the post-session scores were generally lower than the pre-session scores for the  $F_0$ , SVS and slope given that fatigue leads to a lowering of vocal pitch and reduced vocal expressivity (Aronson, 1990; Bunch, 1997; Pittman, 1994; Stengel & Strauch, 2000). In contrast however, long term increases in feelings of fatigue were also reported and this did not correspond with decreases in  $F_0$  and SVS. Therefore, increases in fatigue experienced by subject D may have only influenced the immediate effects of treatment and not the long term effects. This finding further supports the notion of the existence of cumulative effects of treatment alluded to earlier.

### 5.6.4 Pitch matching in exercises and songs

The following section reports and discusses the findings regarding the ability of subject D to sing intervals within PME and within song phrases (PMS). This section follows the same format as that detailed for subject B (5.4.4).

#### *Pitch matching exercises*

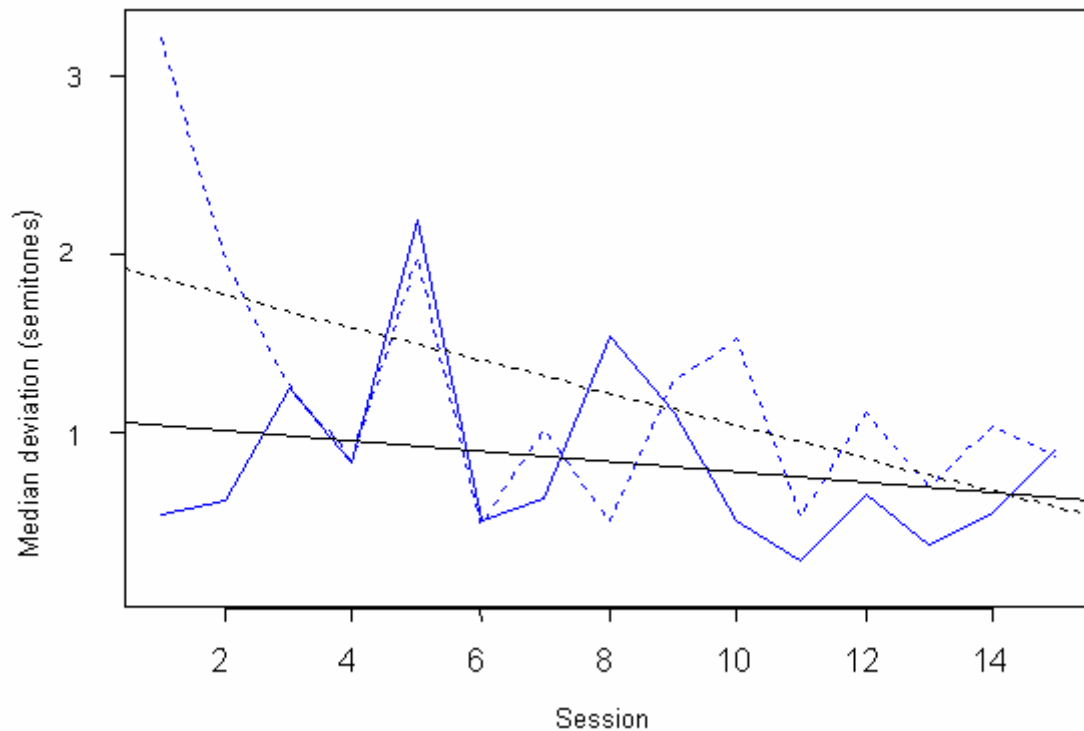
Figure 48 illustrates how subject D varied in his accuracy of reproduction across different intervals. Here, the y-axis reports the median number of semitones subject D deviated above or below the target reproduction of each interval.



**Figure 48. Subject D: Differences between intervals in pitch matching exercises**

Overall, subject D was found to be poor at reproducing intervals contained within the PME. The intervals that emerged as being the most difficult to reproduce were the larger and more difficult intervals of the augmented 4<sup>th</sup>, minor 6<sup>th</sup>, major 6<sup>th</sup> and minor 7<sup>th</sup> (with the exception of a minor 2<sup>nd</sup> which was also poorly replicated).

Figure 49 details the immediate and long term changes in pitch matching accuracy when the data from all the intervals were pooled. Again, the y-axis reports the median number of semitones subject D deviated away from accurate interval reproduction.



**Figure 49. Subject D: Trends in pitch matching exercise**

Subject D improved in his ability to reproduce intervals over time suggesting he was better able to control his voice in the longer-term (q.2c). There were marked differences in his ability to reproduce intervals from pre- to post-session, with the accuracy in the post-session tasks higher than the pre-session. This is particularly observable from session ten onwards where the raw data obtained at the post-sessions followed the same pattern as the raw data obtained at the pre-sessions but were between a half to one semitone more accurate than the pre-session data.

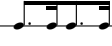
### ***Pitch matching in songs***

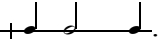
The three songs selected by the music therapist treating subject D were chosen from a limited list of subject-preferred songs as given by the subject and his family:

- *Layla* by artist Eric Clapton
- *Bad Moon Rising* by artist Creedence Clearwater Revival
- *Sunday, Bloody Sunday* by artist U2.

*Layla* is a song about the desperation of a man who longs for his partner Layla to return. The man's wife has committed adultery and this song is portrayed through his eyes. The song typifies popular song structures containing three verses and a chorus. The melodic range is limited to a minor 6<sup>th</sup> with the largest interval leap being that of a perfect 4<sup>th</sup>, this only occurring three times throughout the entire song. Stepwise melodic motion predominates throughout the song. The verses are built around D<sup>b</sup> minor and this modulates to D minor in the chorus. It is harmonically interesting and rich with an overall minor feel portrayed in the following chordal progressions:

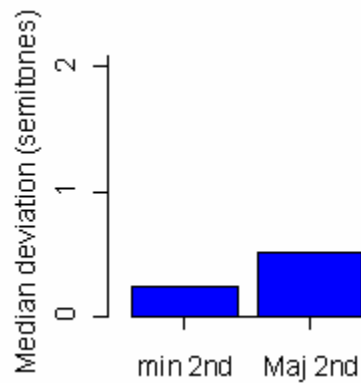
- a) D<sup>b</sup> minor, A<sup>b</sup> minor, C major, D major, E major, F<sup>#</sup> minor, B major, E major and A major for the verse and
- b) A major, D minor, B<sup>b</sup> major and C major for the chorus.

The tempo of the song is moderate with a  rhythmic feature predominating but not played in strict time. The song portrays a feeling of sadness and longing.

The song *Bad Moon Rising* contains three verses and three choruses and is set in the key of D major. The theme of the text is about the anticipation of misfortune through the metaphor of the *Bad Moon Rising*. The misfortune is supposedly a result of some form of revenge (*one eye is taken for an eye*). The range of the song is a perfect 4<sup>th</sup> from D<sup>4</sup> to G<sup>4</sup>. The melodic line comprises mostly unison and stepwise motion with occasional major 3<sup>rds</sup> and perfect 4<sup>ths</sup>. There is a static and tense feeling evoked from the melody line. The harmony is centered on the tonic, dominant, subdominant and supertonic chords (D major, A major, G major and C major), but despite its major key, the overall effect portrayed is one of a minor feel. The tempo is moderately fast and the melody and accompaniment typically contains a crotchet-minim-crotchet rhythmic pattern .

Of the aforementioned three songs, *Sunday, Bloody Sunday* was selected as the song to be used for analysis. *Sunday, Bloody Sunday* was a popular song written and

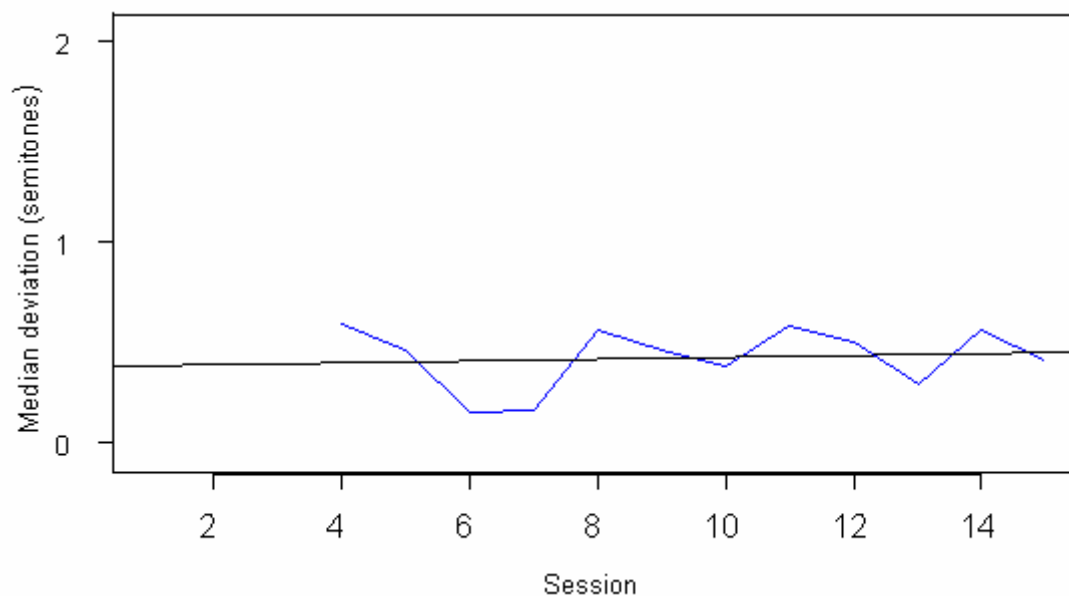




**Figure 51. Subject D: Differences between intervals in song phrases**

The results indicate that subject D produced intervals that were less than a semitone in deviation from accurate interval reproduction. He was more accurate in his production of a minor 2<sup>nd</sup> when compared with the major 2<sup>nd</sup>.

Figure 52 details the change in accuracy of intervals over time, when data from both intervals were pooled. As with the PME, the y-axis reports the median number of semitones subject D deviated away from accurate interval reproductions.



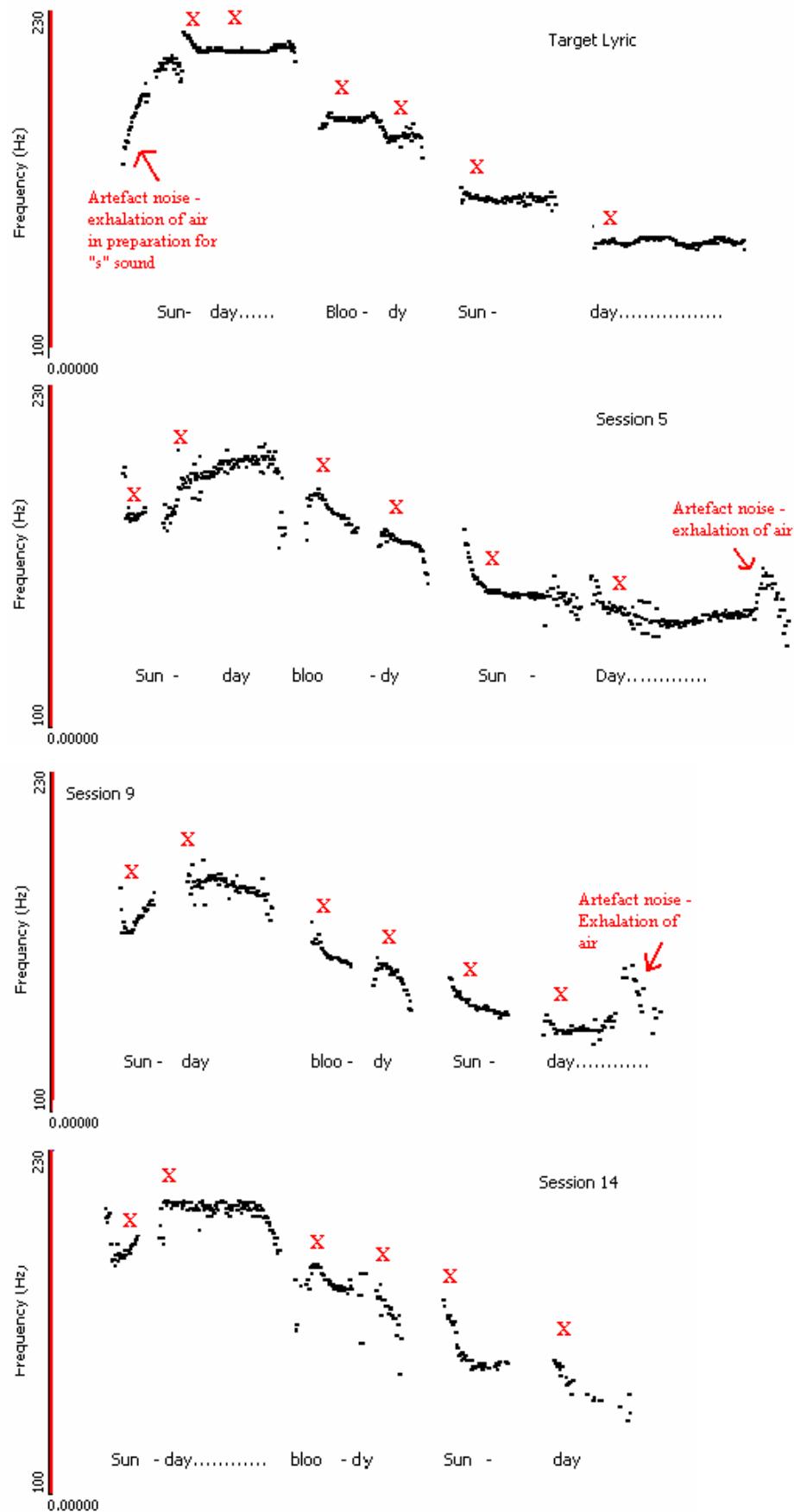
**Figure 52. Subject D: Trends in pitch matching in songs**



The figure illustrates that there was a slight decrease in the accuracy of interval reproduction over time (q.2c). This does not align with the improvements noted in the PME.

### ***Analysis of song contours***

This section documents the results of the contour analysis for the song phrase *Sunday, bloody Sunday* for three of the four sessions chosen for analysis (sessions five, nine and 14). Session one could not be analysed as the song material from this session was corrupted. In Figure 53, the first contour (top) is the target phrase sung by the treating music therapist, who gives the most accurate reproduction of the phrase. The remaining contours are those produced by subject D during sessions five, nine and 14.



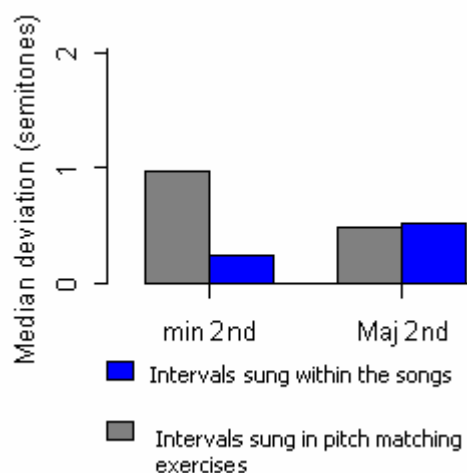
**Figure 53. Subject D: Contours for selected song phrase**

These contours show a long term progression of improvement in control of pitch (q.2c). It is clear that subject D was more able to produce clean and clear pitch changes in session 14 when compared with session five. Similarly, the contour in session 14 is closer in shape to the target phrase sung by the therapist than the two earlier sessions. Further, the highest pitch (the first two syllables), was sung higher and more accurately, and able to be sustained during session 14 when compared with the earlier sessions.

These contours illustrate a gradual improvement in pitch control developed by subject D over time. However, this is in contrast to the numerical data reported in Figure 52 which showed that accuracy in interval reproduction decreased slightly over time. This can be explained by the fact that the two analyses are focusing on different aspects of pitch control – the PMS examines specific interval reproduction whereas the contours assess the ability to move between two pitches quickly and smoothly, and the ability to sustain pitch when required.

### ***Comparison between pitch matching exercises and pitch matching in songs***

Figure 54 compares the two intervals from the PMS with those in the PME.



**Figure 54. Subject D: Accuracy differences between pitch matching exercises and pitch matching in songs**

This figure shows that subject D demonstrated greater ability to sing the intervals accurately when they were placed in the context of a song than when presented in an exercise. However, this finding must be viewed with caution as there were only two intervals analysed in the PMS. Further, both of these intervals were small and were previously shown to be more accurately produced than the larger intervals.

### ***Discussion of pitch matching in exercises, songs and other measures***

It is difficult to ascertain with certainty whether singing songs assisted in improving the ability to sing intervals in the PME (q.3c). Evidence that there was a post-session increase in accuracy and over time supports this idea. However, the pure repetition of this exercise during each session also might explain the overall improvement in the PME.

The improvements noticed in the PME and song contour analyses are indicative of improvements achieved in subject D's pitch control. This implies that he has more control over his placement of two pitches relative to one another. Such improvements in control, particularly in the upper frequencies, are reflected in his increased ability to manipulate the  $F_0$  and SVS when expressing happiness and anger. This suggests that improved pitch control may be linked with improvements in the use of voice in speaking. Improvements in the singing of large intervals by subject D may also be linked to an enhanced ability to create steeper slopes when expressing anger. The expression of anger typically utilises larger and faster changes in pitch when compared with other emotions (Apple et al., 1979; Davitz & Davitz, 1959; Fairbanks & Provonost, 1939; Mozziconacci & Hermes, 1997; Murray & Arnott, 1993; Pittman, 1994; Scherer, 1991).

The results reported earlier showed that the VR of subject D was widened over the course of the program – from approximately 11 semitones to approximately 18. Only one song contained a wide pitch range (Sunday bloody Sunday) of 15 semitones which is likely to have contributed to some of the improvements subject D made over the course of the program. The remaining two songs only utilised a narrow pitch range of a minor 6<sup>th</sup> and a perfect 4<sup>th</sup>. Perhaps the mere act of singing itself assists in strengthening vocal muscle control, thereby increasing its potential to reach higher and lower notes.

#### **5.6.5 Post-treatment assessment of pitch discrimination**

At the completion of the treatment program, subject D was asked to repeat two of the exercises included in the pre-selection tasks to determine whether there were further improvements in his pitch discrimination and intonation discrimination abilities. The post-treatment reassessment indicated that subject D increased his accuracy in pitch discrimination from 70% to 90% and slightly decreased his accuracy in affective intonation discrimination from 100% to 90%.

To determine whether subject D perceived changes in his vocal expressive potential, he was asked to indicate on a post-treatment questionnaire whether he perceived

any improvements in his voice post-treatment. The results revealed that subject D perceived a slight improvement in his voice overall, and a notable improvement in his expression of emphasis and emotion.

### 5.6.6 Summary and Conclusions

Results of the 15-session music therapy program showed that singing songs had a positive effect on the expressive speaking potential of subject D (q.1). As indicated by the speech pathologist and family report, subject D initially displayed difficulty in manipulating the  $F_0$ , SVS and slope to create intonation contours representative of different emotions (q.4). Following treatment he was better able to manipulate  $F_0$  and apply more variability in his intonation to express emotions. The implications of these improvements might include an enhanced potential for accurate expression of emotion and therefore an increased ability to be understood by listeners. However, when compared with the non-clinical sample, it is clear that subject D continues to have substantial difficulty in this area and further treatment is recommended.

It was noticeable that subject D increased his VR over the program and that there appears to be a link between that increase and an increase in the  $F_0$  and SVS (q.2a, q.3a). Because subject D generally reported a flat affect both pre- and post-session and over time, it was not possible to establish what effect the treatment had on his mood (q.2b, 3b). However, some links can be found between his increase in tiredness from pre- to post session, and a corresponding decrease in the SVS and  $F_0$  from pre- to post session. Given that therapy is hard work, and fatigue is typical in TBI, it is not surprising that fatigue may result from participating in a therapy that requires both cognitive and physical participation.

Improvement in interval reproduction and pitch control appeared to have a direct link with improvements in the  $F_0$  and SVS (q.3c). In particular, the improvements made to larger intervals may have assisted in producing more flexibility in the voice thereby allowing more variability in contours and greater use of higher frequencies.

In conclusion, subject D was responsive to the singing program and showed improvements in his speaking voice over the course of the 15 sessions.

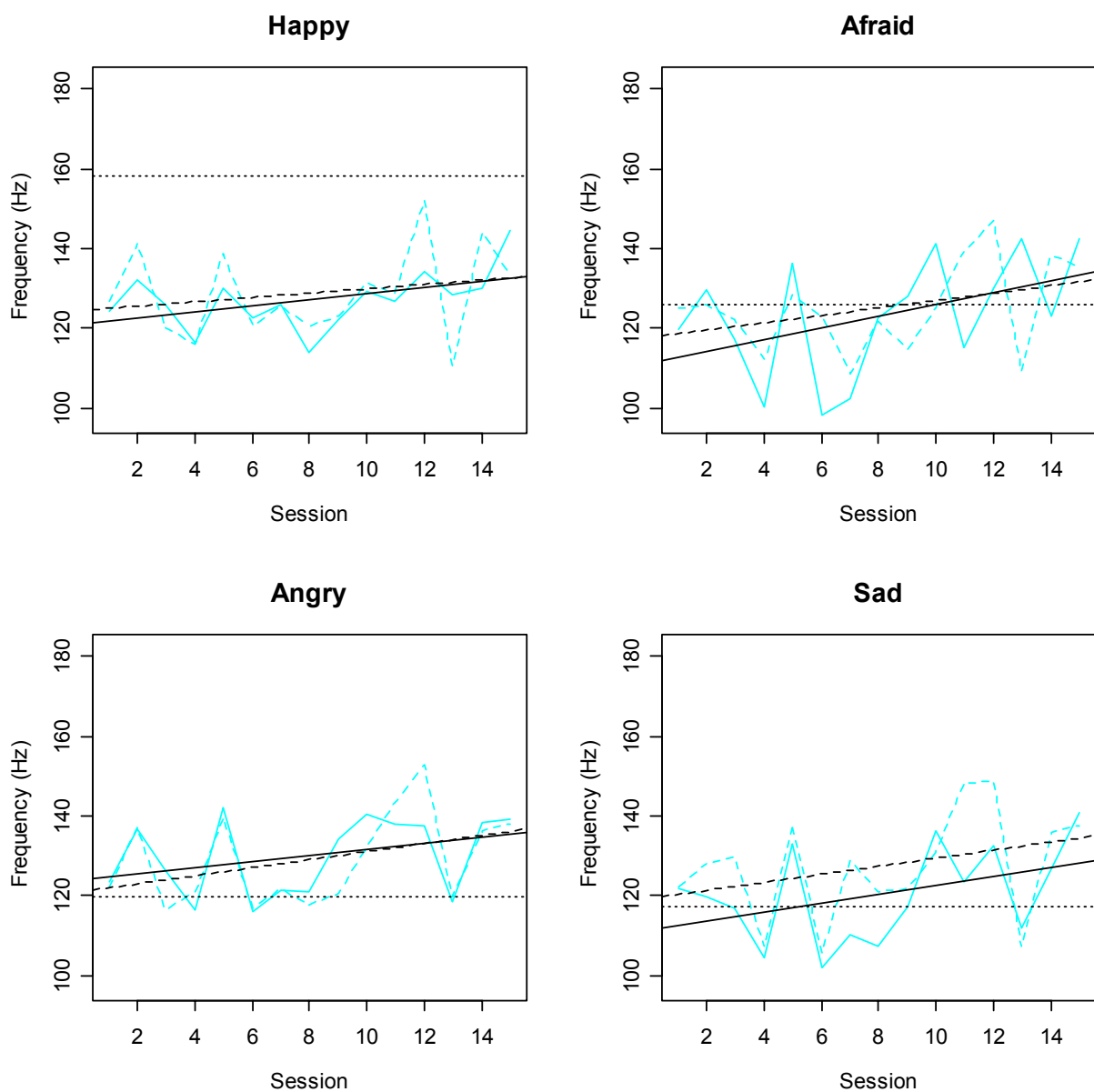
## 5.7 Subject E

### 5.7.1 Sentence material

The following section details and discusses the responses of subject E within the sentence reproduction tasks for the parameters of the  $F_0$ , SVS and slope.

#### *Fundamental frequency*

Figure 55 illustrates the immediate and long terms trends for subject E's  $F_0$ .



**Figure 55. Subject E: Trends in fundamental frequency**

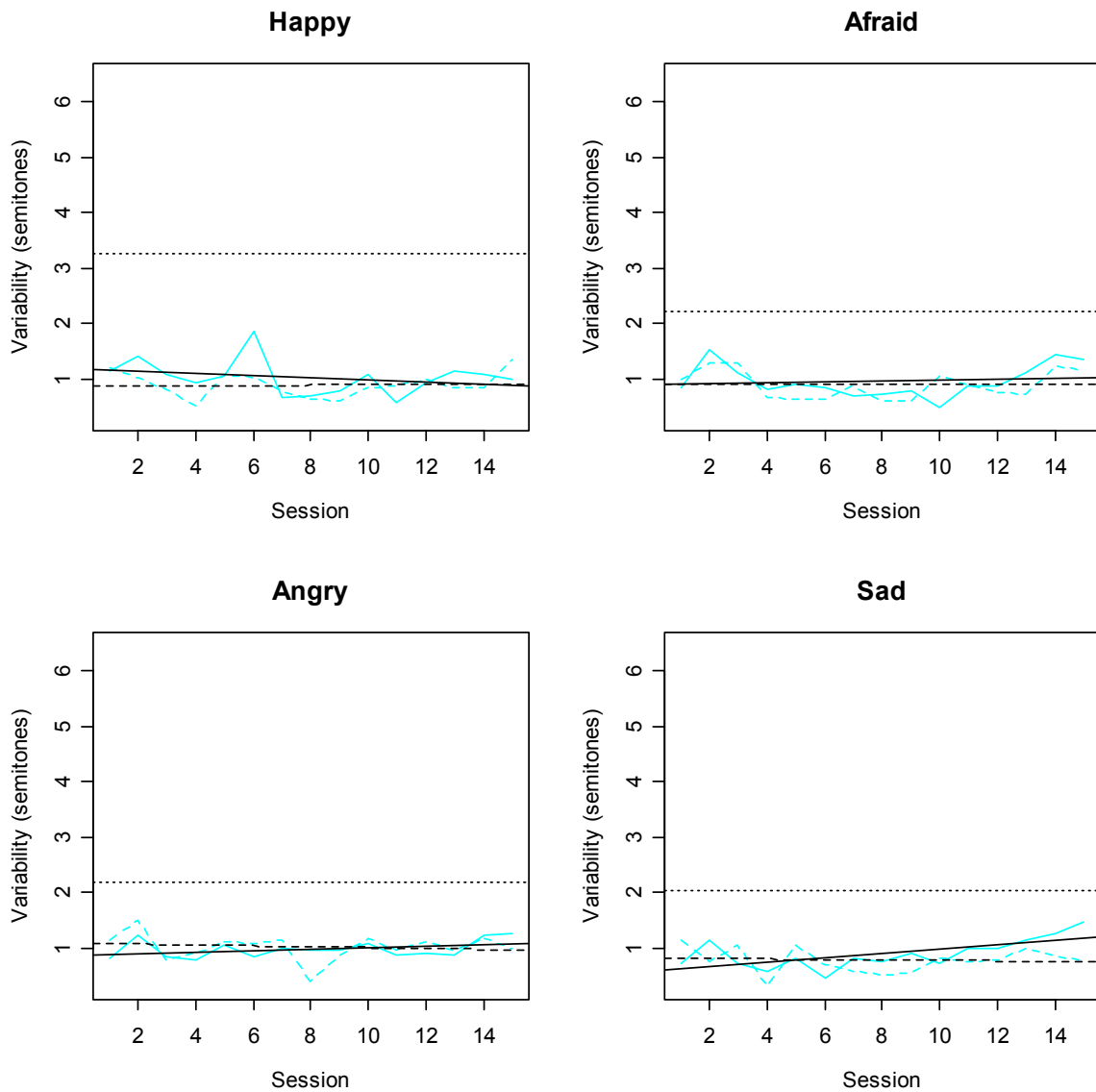
Figure 55 shows that in the long term, subject E was able to produce sentences that utilised higher levels of  $F_0$  than those initially produced. These changes were particularly noteworthy when subject E attempted to inflect sentences to express sadness or fear. However, this figure also illustrates that apart from the  $F_0$  produced to express happiness, subject E displayed  $F_0$  responses that were generally higher than those of the non-clinical sample, even during the initial stage of treatment.

With the exception of the expression of anger, the pre-session scores were generally higher than the post-session scores, although the pre/post differences became less accentuated (happy and angry) and even reversed (afraid) over time. It is noticeable that the post-session data measurements for the sentence expressing sadness were lower than the pre-session measurements throughout the entire program.

When comparing the  $F_0$  between the different sentences at the commencement of the program, similar responses were produced for each of the four sentences. The exception to this were the  $F_0$  responses produced during the expression of sadness, where the height of the  $F_0$  was lower than that used to express the other emotions. Although the  $F_0$  for all sentences increased over time, there was no substantial increase in the ability of subject E to differentiate between them, with the  $F_0$  at session 15 being similar across all four sentences. Further, the lack of differentiation between the sentences is marked when compared with that of the non-clinical sample.

### ***Standardised variability score***

Figure 56 illustrates the immediate and long term changes in the ability of subject E to manipulate SVS in order to express four different emotions.



**Figure 56. Subject E: Trends in standardised variability score**

Figure 56 illustrates how the SVS responses of subject E were well below the mean for the non-clinical sample for all four sentences. It also shows that levels of SVS increased slightly for three of the four sentences (sentences expressing fear, anger and sadness) and decreased in the remaining sentence (happy). However, given the substantial impairment subject E displayed in his ability to use SVS in his voice, even this small improvement is regarded as important.

Immediate changes in SVS from pre- to post-session were minimal and patterns across the four sentences were not consistent. The SVS trend lines for the sentences of angry and sad show that the pre-session responses were higher than the post-session

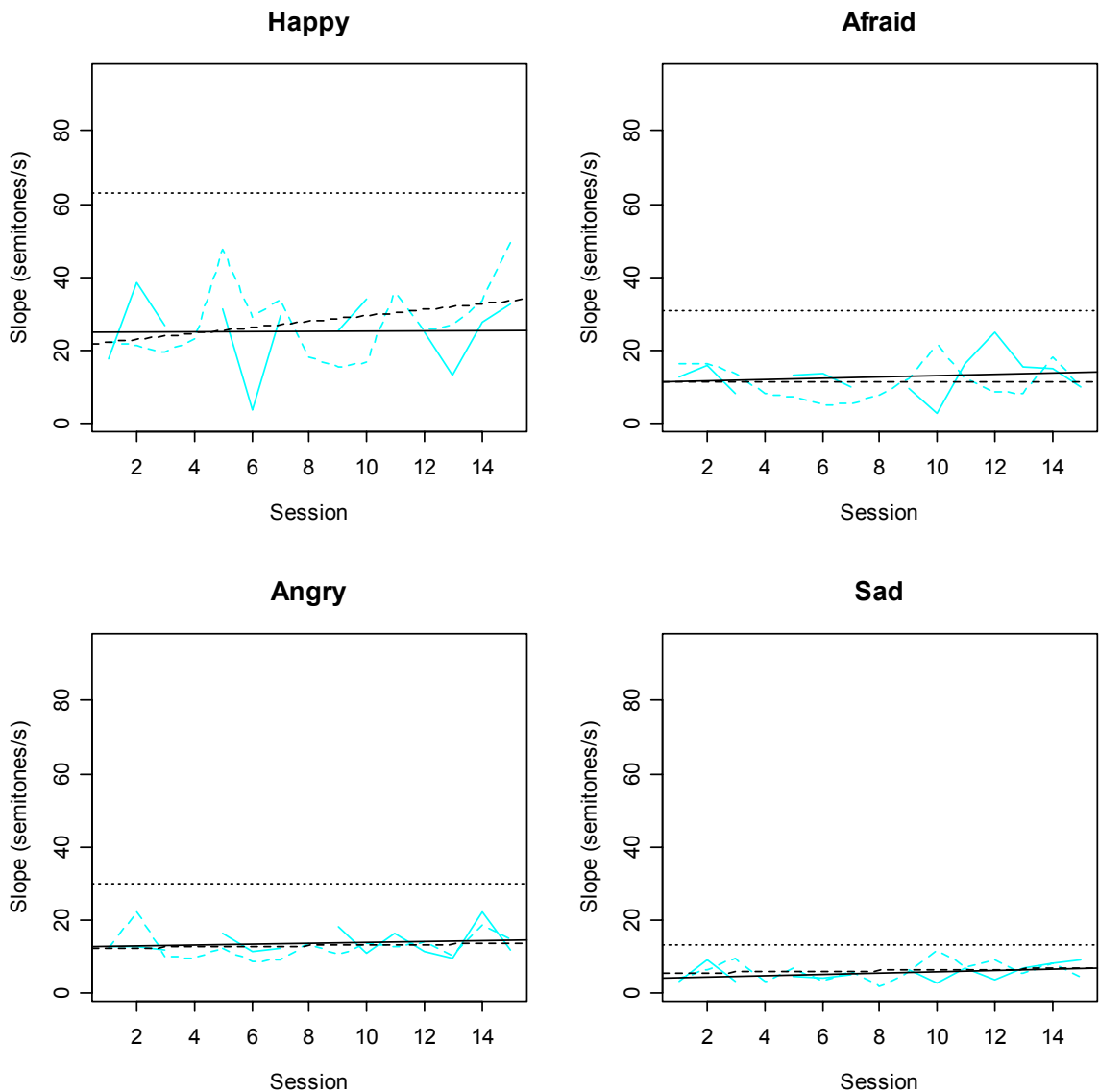


responses, this trend reversing as the program progressed. Conversely, the SVS trend line for the sentence expressing happiness displayed a higher post-session trend at the commencement of the program, while the reverse occurred at the conclusion of the program.

This figure also illustrates that subject E displayed no improved ability to use differentiated SVS to express different emotions, despite a decrease in his monotonal pitch patterns.

*Slope*

Figure 57 shows the immediate and long term effect of treatment on subject E’s slope.



**Figure 57. Subject E: Trends in slope measures**

The figure illustrates that subject E was able to produce slightly steeper slopes during his speech, suggesting that he became better at using slope to express emotion. The pre-session trend line for the sentences expressing happiness increased to the most. The post-session trend line for the sentence expressing happiness would have followed a similar pattern except that a large and unexplainable dip in the data occurred in session six, which considerably affected the trend line.

The figure shows that subject E became better able to use slope to differentiate between the different emotions, this being evidenced by the observation that some slope trend lines (happy and angry) increased over time to a larger degree than others (sad and afraid). However, subject E remains considerably impaired in his ability to use steep slope contours when compared with the non-clinical sample.

Generally there were negligible differences between the pre- and post-session responses for slope with the exception of the data from the sentence expressing happiness where the pre-session slope responses were steeper (larger) than the post-session responses, particularly at the end of the treatment program.

### ***Discussion of sentence measures***

Prior to commencing the study, subject E was subjectively described by the speech pathologist as having a low  $F_0$ , a flat or monotonal speaking style and poor pitch control. Further, the family of subject E reported that his  $F_0$  was considerably lower post-trauma. However, evaluation of his  $F_0$  at the commencement of the program indicated that his pitch height was appropriate for his age as given by the mean  $F_0$  for the non-clinical sample. Even so, his use of slope and SVS was considerably impaired when compared with the non-clinical sample. This predisposed subject E to difficulties in effective expression when engaged in conversations with people. His poor ability to use varying levels of  $F_0$ , SVS and slope to differentiate between different emotions placed him at risk of his emotional state being misunderstood.

Following participation in the treatment, subject E displayed increased potential for effective expression as evidenced by the large increases in  $F_0$  and the small increases in SVS and slope (q.1). Subject E displayed a long term increase in his ability to differentiate between the different emotions through his use of SVS, and to a lesser extent, slope, but there were no such increases in his ability to differentiate between the mood states in his use of  $F_0$  (q.4). While long term improvements were evident, he remained noticeably

impaired in his use of SVS and slope when compared with the non-clinical sample. As subject E made slow and steady increases in his SVS and slope, and showed no evidence of a plateau in response, it seems reasonable to suggest that further treatment would continue to have a positive effect on him.

The increases in the three variables could possibly be explained by:

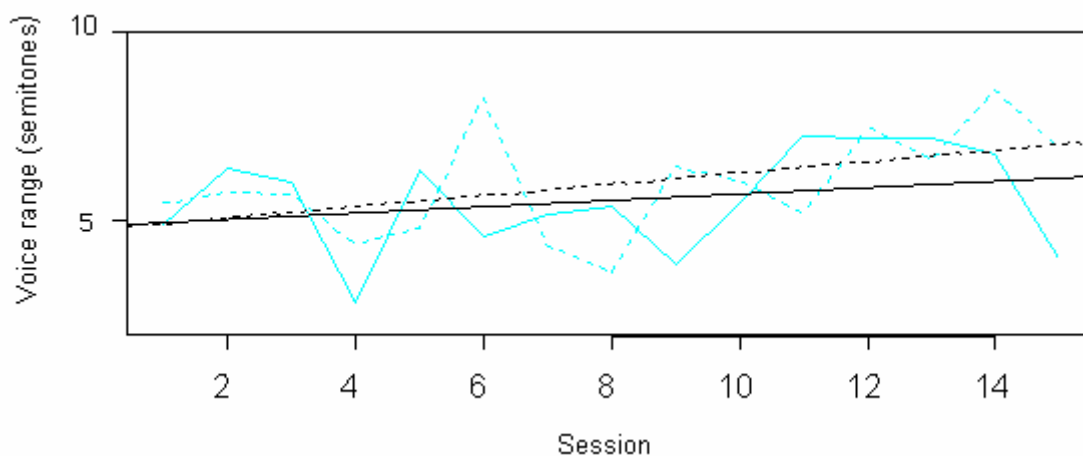
- an increase in vocal fold flexibility (Colton & Casper, 1996; Sonninen & Hurme, 1998);
- an increase in vocal range; an increase in pitch control;
- a decrease in vocal tension (Aronson, 1990); or
- an increase in affect (Alpert et al., 2001; Frolov et al., 1999; Garcia-Toro et al., 2000; and Kuny & Stassen, 1995).

These possibilities are discussed in conjunction with the reports of changes in vocal range (5.7.2) and mood states (5.7.3).

The immediate effects of treatment did not show any particular pattern between sentences or between the three different intonation measures and therefore no specific conclusions can be drawn with regard to the immediate effects of treatment.

### 5.7.2 Vocal range

The next section reports and discusses changes in the VR of subject E and how these changes relate to changes in his intonation data. Figure 58 illustrates the immediate and long term changes in the VR of subject E.



**Figure 58. Subject E: Trends in vocal range**

By following the pre-session trend line from the beginning to the end of the program, it can be seen that the VR of subject E increases from approximately five semitones at the commencement of the program, to approximately seven semitones at its conclusion. This is a considerably large increase in VR given the short time frame of the program.

The pre- and post-session trend lines show that the immediate effects of treatment are in the direction contrary to that expected, whereby the post-session VR is narrower than the pre-session VR. However, it is also noticeable that the post-session trend line is affected by the unexpected fall in the post-session VR at session 15.

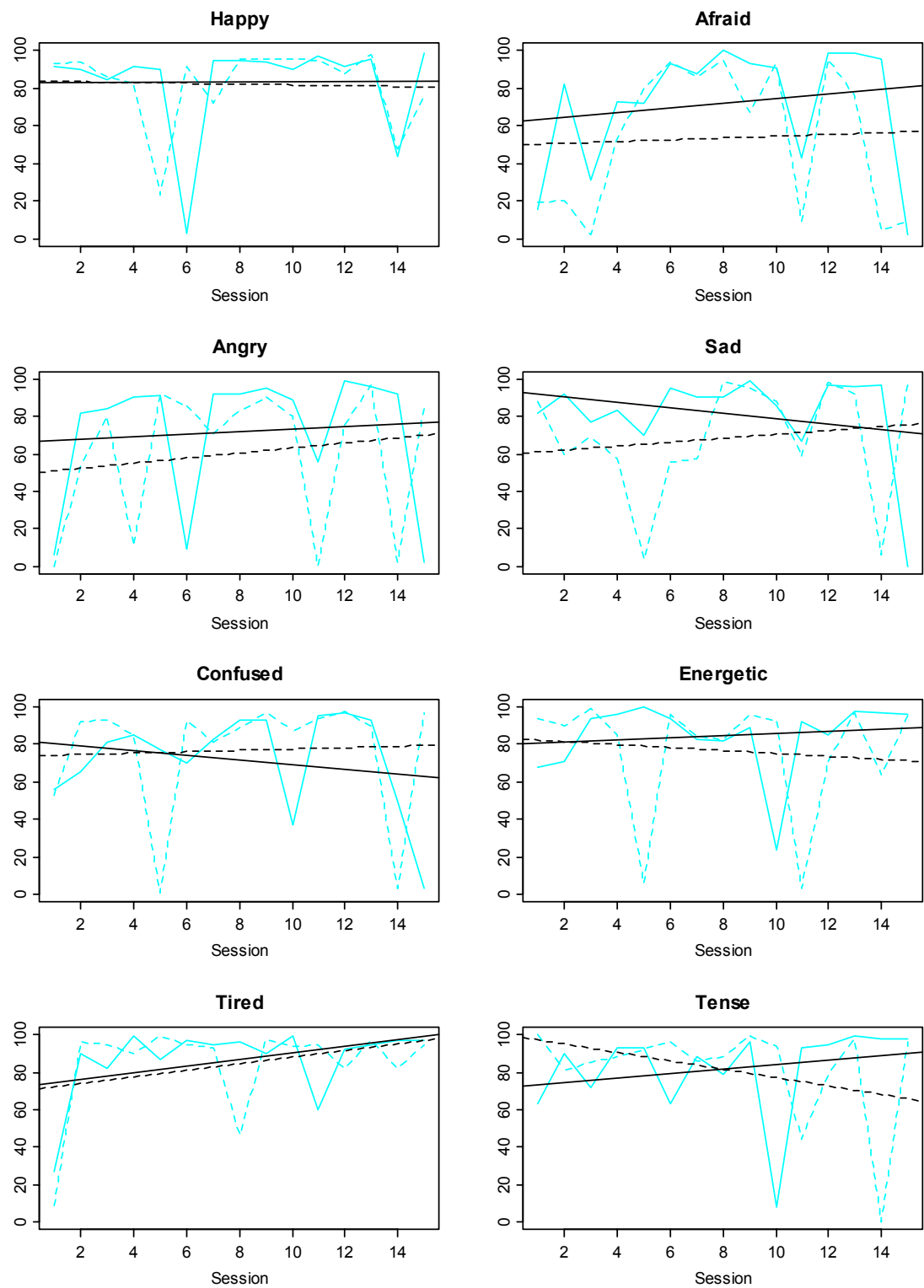
It is observable that there is an almost continuous pattern of increase in VR throughout the program with the pre-session data showing a steady and consistent increase from session nine onwards. An absence of a plateau in response would suggest continued treatment might lead to a further widening in VR for subject E.

### ***Discussion of vocal range and sentence measures***

Results indicate that as VR increased, measures of the  $F_0$ , SVS and slope also increased (q.2a). This points to a potential positive correlation between these vocal parameters. This would be expected given that one requires a sizeable VR in order to achieve wide SVS and steep slopes. As subject E initially displayed a very narrow VR, this increase in VR is likely to have a positive impact on his ability to express emotions more effectively and expressively.

### **5.7.3 Visual analog mood scale**

The next section reports and discusses the immediate and long term effects of treatment on the mood of subject E and relates these to changes in his changes in intonation. Figure 59 displays the mood changes reported by subject E from pre- to post-session and over time.



Key:  $x$ -axis = session number,  $y$ -axis = VAMS score (out of 100).

**Figure 59. Subject E: Trends in visual analog mood scale scores**

Subject E reported experiencing high and variable mood states across the eight different mood descriptors both within sessions and over time (q.2b). According to trend lines, immediate effects of treatment indicated an increase in fear, anger, and sadness. Long term effects were similar with increases in fear and anger reported. Increased feelings of fatigue (but also energy) were reported over the course of treatment. Results should be viewed with caution given the polarized responses frequently recorded. Large immediate (pre- to post-session) changes in mood were reported in sessions six, ten, 11 and 14.

### ***Discussion of mood and sentence measures***

Subject E reported a range of different moods and changes to mood within sessions and over time (q.2b). He reported experiencing high levels of different feeling-states, which may indicate that he displayed an ability to reflect upon and have insight into his emotional state. However, his frequent polarized responses might suggest he was not able to accurately evaluate the level of his feeling states. Difficulties in identifying and measuring mood states are common impairments in people with TBI (Oddy et al., 1985; Prigatano, 1999b; Prigatano & Schacter, 1991). Nevertheless, subject E was consistent in describing an overall increase in the negative feeling states –anger and fear – suggesting that he was able to, at the very least, report an increase in experiencing these mood states. Anger and fear are mood states typically experienced by people with TBI (Bowen et al., 1998; Prigatano, 1999a; and Schramke et al., 1998). As was noted with other subjects, feelings of tiredness progressively increased throughout the program.

Some relationship between mood change and the sentence measures were found when viewing the data (q.3b). During session six, subject E became both less angry and less happy at the end of the session (flatter affect). This aligns with a corresponding decrease in the  $F_0$  for afraid, and a lower than average  $F_0$  for angry and sad during that session. Such decreases in  $F_0$  may be indicative of reduced vocal tension. Such differences were not noted for SVS. For slope, the happy sentence slope fell substantially at the post-session, suggesting that a flattening of affect may also influence slope.

At the conclusion of session ten, subject E reported experiencing decreased feelings of confusion, energy and tension (although feelings of fear remained high both pre- and post-session). This aligns with an increased  $F_0$  for the afraid and angry sentences. As with session six, increases in SVS or slope were not noted. Because the subject felt less tense and more energetic, it is possible to suggest that a decrease in tension and increase in

energy enabled the vocal folds more flexibility and the possibility of utilising a higher pitch height (Leonard et al., 1988).

The relationships become more complex when reviewing the sentence measures and mood changes for session 11 and 14. Session 11 was characterised by an increase in energy and tension at the post-session, with a corresponding decrease in  $F_0$  for all four sentences, particularly afraid and sad. An increase in tension reduces the flexibility of the vocal folds and therefore one would expect the  $F_0$  to increase and not decrease (Leonard et al., 1988). The same could be said when considering levels of energy. One would expect an increase in energy to transfer to the voice with an increased  $F_0$  (Abe, 1980; Kitch & Oates, 1994; and Welham & MacLagan, 2003). No noticeable changes in SVS or slope were observed in session 11.

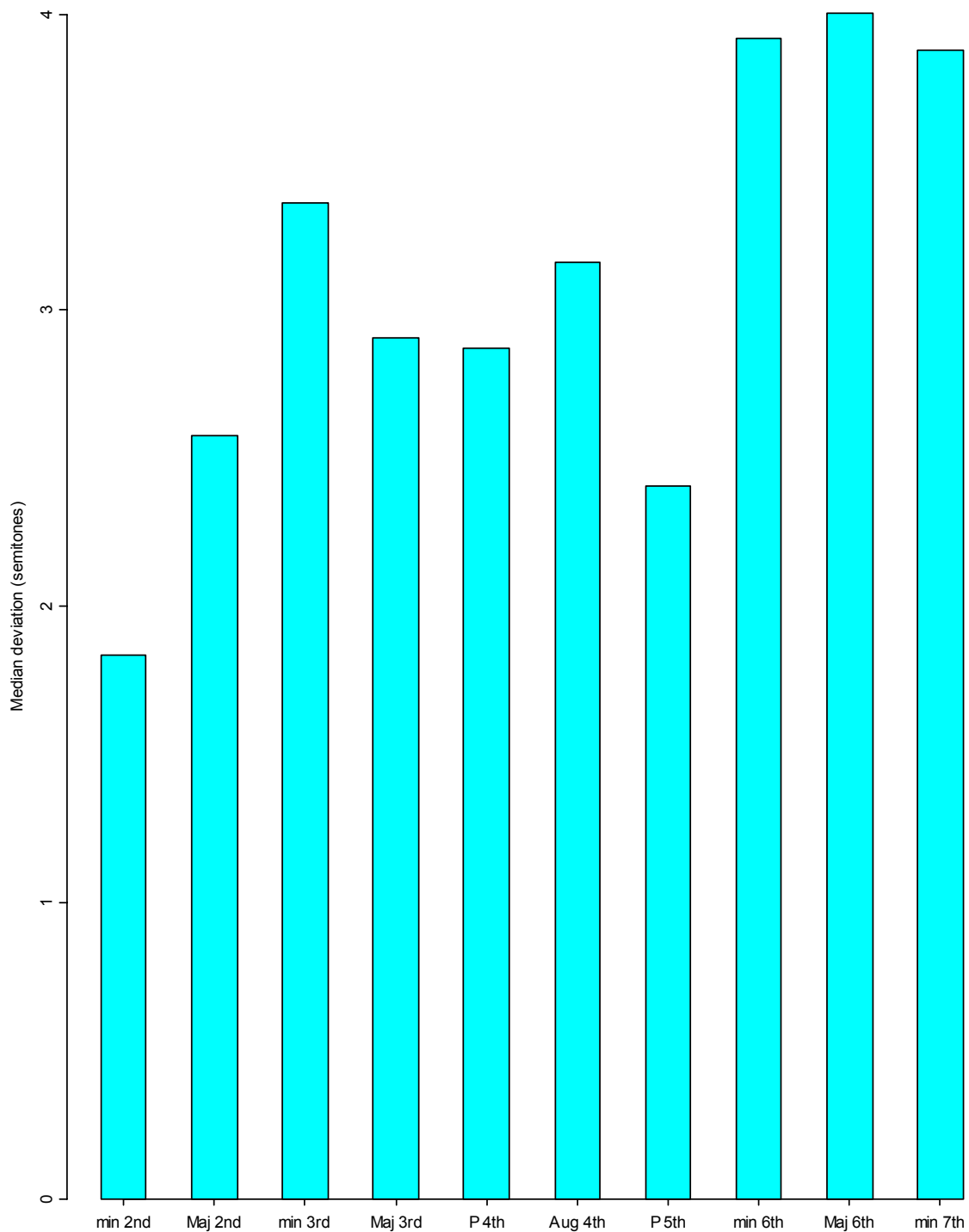
During session 14, there was an increase in fear, sadness, anger, confusion and tension, corresponding with a decrease in  $F_0$  for all sentences except for angry where there was minimal difference. The finding that the  $F_0$  decreased as tension, fear, sadness, anger, and confusion increased, is the reverse to that suggested by previous literature. It was anticipated that a reduction in fear, sadness, anger, confusion and tension would correspond with an increase in  $F_0$ . It is not clear why this was the case. At the same time however, there was also an increase in SVS at the post-session for all four sentences, albeit small increases. This finding was in the direction anticipated, with an increase in affect transferring into an increase in speaking variability.

#### **5.7.4 Pitch matching in exercises and songs**

The following section reports and discusses the findings regarding the ability of subject E to sing intervals within PME and within song phrases (PMS). This section follows the same format as that detailed for subject B (5.4.4).

##### ***Pitch matching exercises***

Figure 60 illustrates how subject E varied in his accuracy of reproduction across different intervals. Here, the y-axis reports the median number of semitones subject E deviated above or below the target reproduction of each interval.



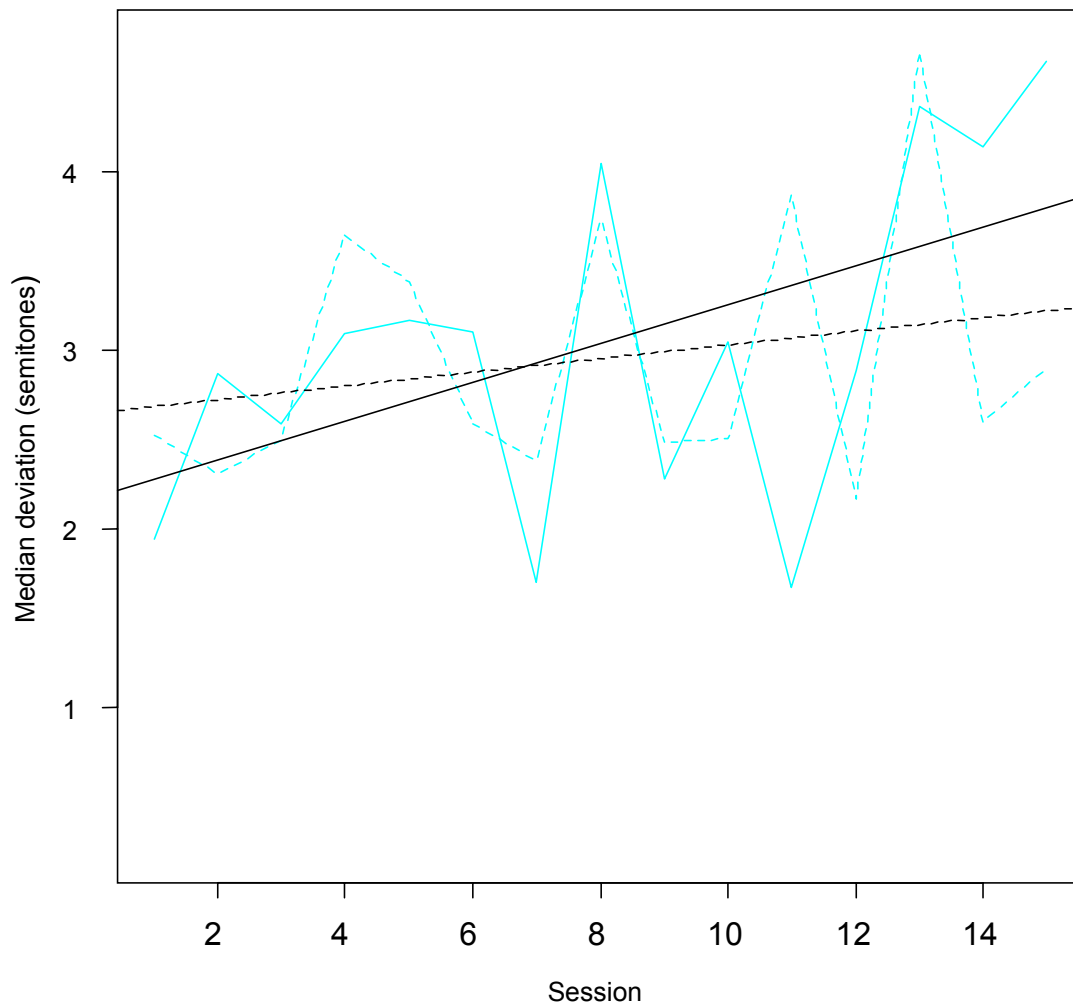
**Figure 60. Subject E: Differences between intervals in pitch matching exercises**

Figure 60 illustrates that the minor 2<sup>nd</sup> and perfect 5<sup>th</sup> were the most accurately produced intervals in the PME. Subject E was least accurate in producing the larger and more difficult intervals - the augmented 4<sup>th</sup>, minor 6<sup>th</sup>, major 6<sup>th</sup> and minor 7<sup>th</sup>. This is not



surprising given his pitch range was limited to between five and eight semitones as shown in Figure 58.

Figure 61 details the change in accuracy of intervals over time, when all the intervals were pooled together. Again, the y-axis reports the median number of semitones subject E deviated away from accurate interval reproductions.



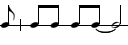
**Figure 61. Subject E: Trends in pitch matching exercise**

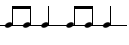
This figure shows that subject E became less accurate over time in his production of intervals (q.2c). Immediate effects show that subject E was initially more accurate post-session but this trend changed over time. It is noticeable that his performance varied significantly from session to session and therefore these results should be interpreted with caution.

### ***Pitch matching in songs***

The three songs selected by the music therapist treating subject E were chosen from a limited list of subject-preferred songs as given by the subject and his family:

- *Cecilia* by artists Simon and Garfunkel
- *Knockin' on heaven's door* the version performed by Guns n' Roses
- *Better man* by artist Pearl Jam

*Cecilia* is a song structured with two-verses, three-choruses and a middle-eight, with a lyrical theme about loss of a love relationship. Although the theme is of loss, the tempo is fast and the overall feel is rhythmic as portrayed by the repeated quavers throughout. The effect is one of a man trying to communicate his devotion to his lost partner. The original key of the song is F major but the song was modulated to the key of C major to accommodate for the VR of subject E. The harmonic chords accompanying the melodic line were C major, F major and G major<sup>7</sup>. The melody line spanned the range of 14 semitones (C<sup>4</sup> to D<sup>5</sup>) with the major 6<sup>th</sup> being the largest interval present. Stepwise motion and the major 3<sup>rd</sup> feature throughout the melodic line. In the accompaniment, the following rhythmic pattern  predominated creating an up-tempo and energetic accompaniment style.

*Knockin' on heaven's door* is a three-verse and three-chorus song that explores issues of death, dying and emotional darkness – through the metaphor *Knockin' on heaven's door*. The melodic line spans a perfect 5<sup>th</sup>, this also being the largest interval used within the song. Stepwise downward melodic motion typifies the melodic style creating a very morbid and depressing mood. This is further accentuated by the use of the D minor tonality (other chords utilized were C major, G major and B minor). The tempo of this song is slow with a two-quaver and crotchet rhythm featured in the melodic line .

The song selected for analysis from the three songs used in the treatment sessions was *Better man* written and performed by the band Pearl Jam. This song was selected because the key phrase in the song (Figure 62) contained the largest interval (a perfect 4<sup>th</sup>) when compared with the key phrases in the other two songs where the largest intervals were 2<sup>nds</sup> and 3<sup>rds</sup>.

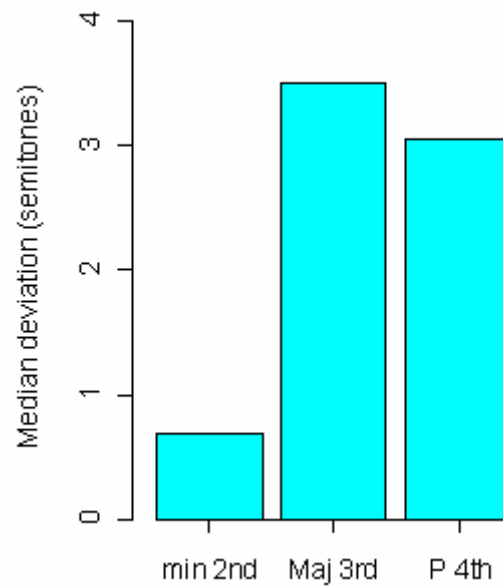
*Better man* is a song comprising of a range of different intervals from stepwise motion, to interval jumps of a perfect 5<sup>th</sup>. The range of the melody line of the entire song is within a major 6<sup>th</sup>. The original recording of the song has a ballad-like style containing a slow, legato melody line, with the chorus phrases syncopated in rhythm. Typically the

phrases descend with the frequent use of a minor 3<sup>rd</sup>. Despite the major key (B major), the minor 3<sup>rd</sup> gives the song a strong minor feel. The song's text is based on a couple where the woman is not in love with the man, despite stating to be, and chooses to stay in a loveless marriage. The texture of the song is thin with an open chordal feel and the accompaniment style comprising of a slow guitar strum with a strong baseline. While the phrase below (Figure 62) is scored in strict common time, in the recording of the song, the rhythmic presentation is more relaxed. The key phrase in this song *Can't find a better man* is a phrase containing the intervals of a unison, a minor 2<sup>nd</sup>, minor 3<sup>rd</sup> and a perfect 4<sup>th</sup>. The phrase itself reflects the normal intonation pattern of the spoken version of this sentence but in a more exaggerated form.



**Figure 62. Subject E: Selected song phrase for analysis**

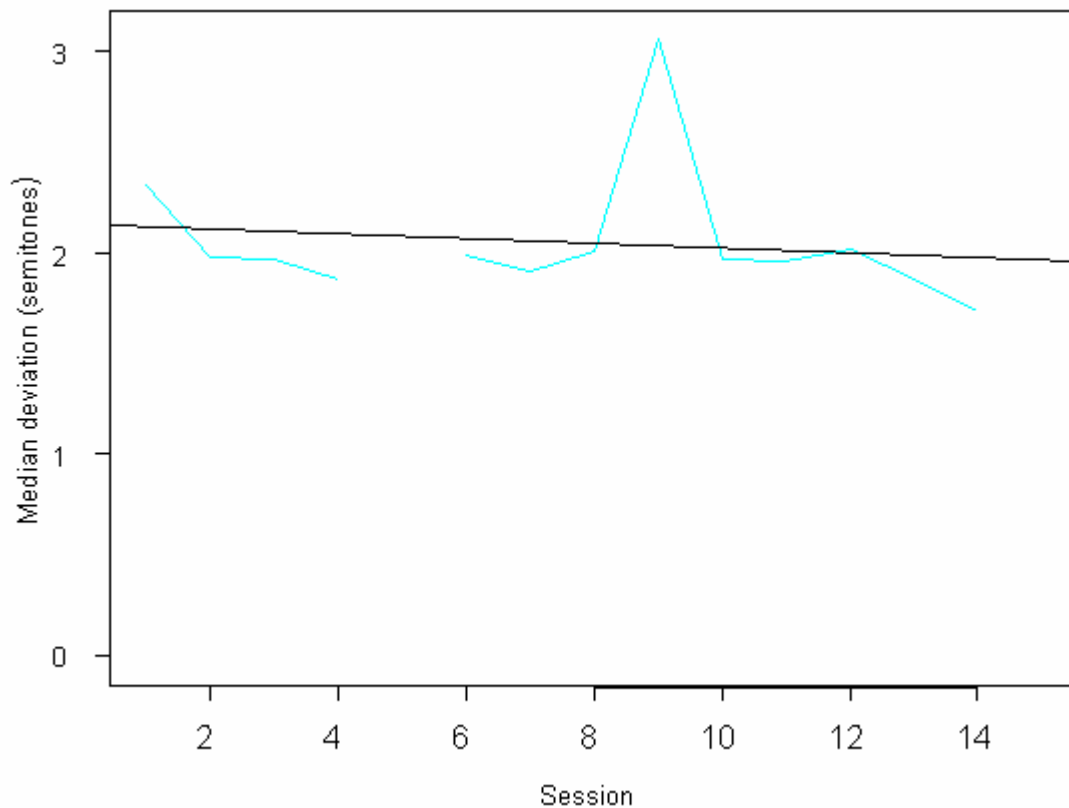
Figure 63 illustrates the degree of accuracy subject E displayed while singing the three interval types contained within the key phrase. As in the PME, the y-axis reports the median number of semitones subject E was away from an accurate reproduction of each interval.



**Figure 63. Subject E: Differences between intervals in pitch matching in songs**

This figure shows that subject E was most accurate at producing the minor 2<sup>nd</sup> and least accurate at producing the major 3<sup>rd</sup>.

Figure 64 details the change in accuracy of intervals over time, when all the intervals are pooled together. As with the PME, the y-axis reports the median number of semitones subject E was away from accurate interval reproductions.



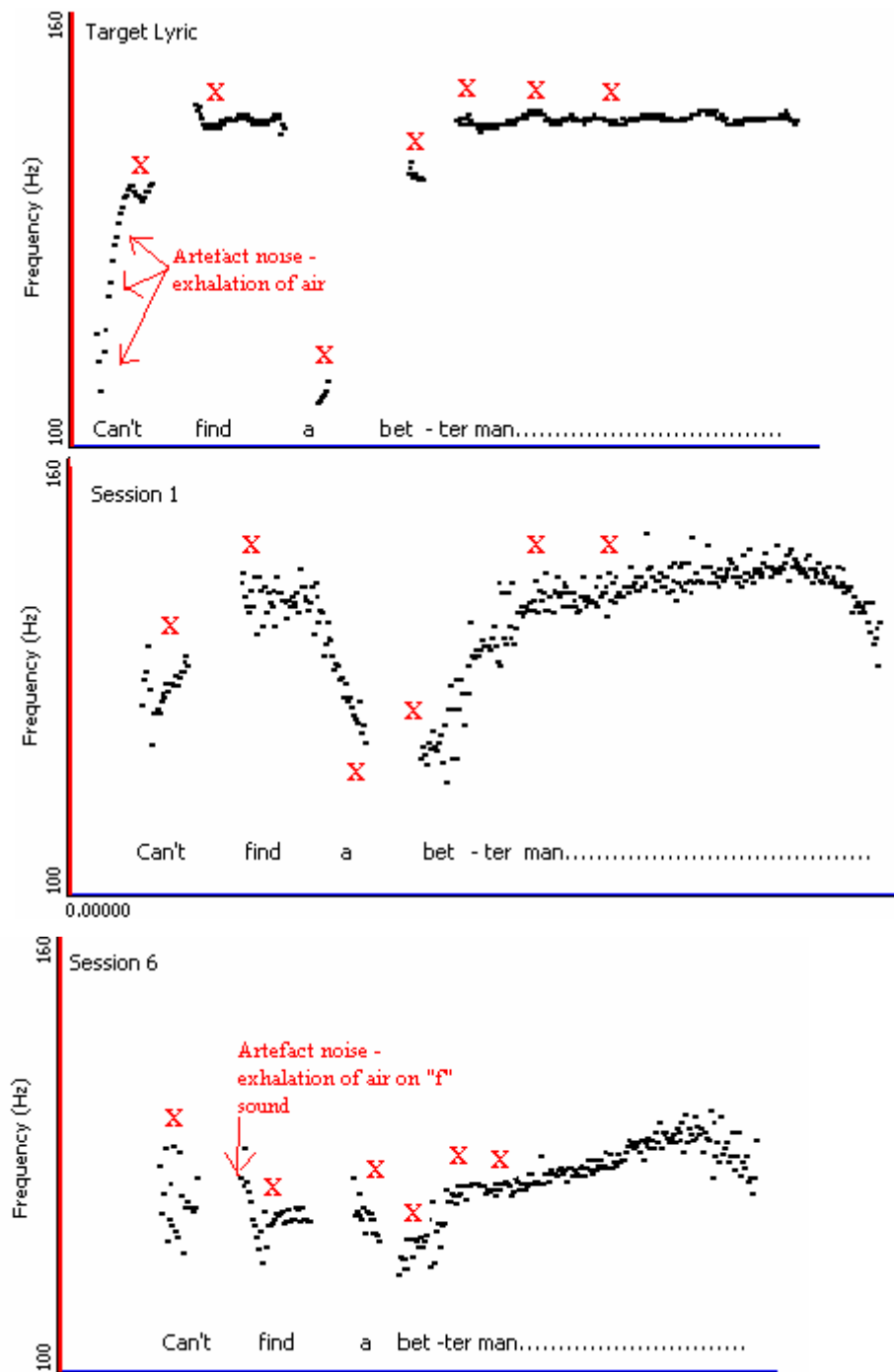
**Figure 64. Subject E: Trends in pitch matching in songs**

Here, subject E became progressively more skilled at singing the melody line of the song phrase over the course of treatment (q.2c). The exception was for session nine where there was an unusual and unexplainable decrease in accuracy (increase in deviation). In the long term, subject E performed more accurately and significantly more consistently in the PMS when compared with the PME. However, these results should be interpreted with caution because subject E did not sing intervals larger than a perfect 4<sup>th</sup> in the song phrases.

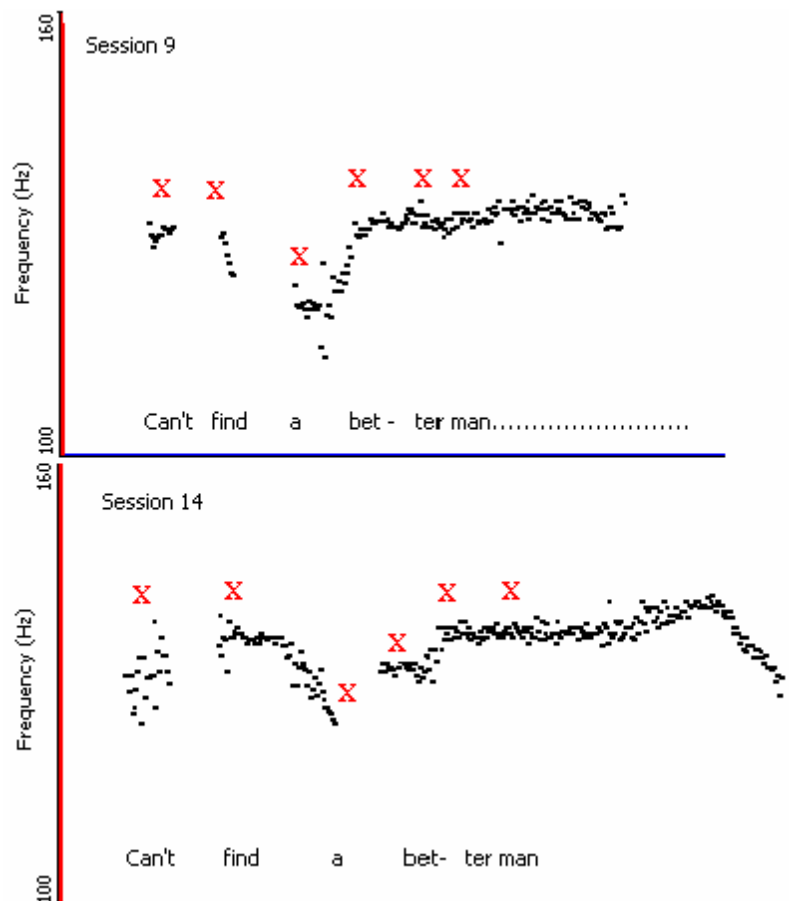
### ***Analysis of song contours***

This section documents the results of the contour analysis for the song phrase *Can't find a better man* for four sessions chosen for analysis (sessions one, six, nine and 14). It was planned to analyse the song phrase from session five but this material was contaminated and deemed unusable and consequently discarded. Audio material from session six was included as a compromise. In Figure 65a, the first contour (top) is that sung

by the therapist. The following contours in Figure 65a and 65b are those sung by subject E in sessions one, six, nine and 14.



**Figure 65a. Subject E: Contours for selected song phrase**



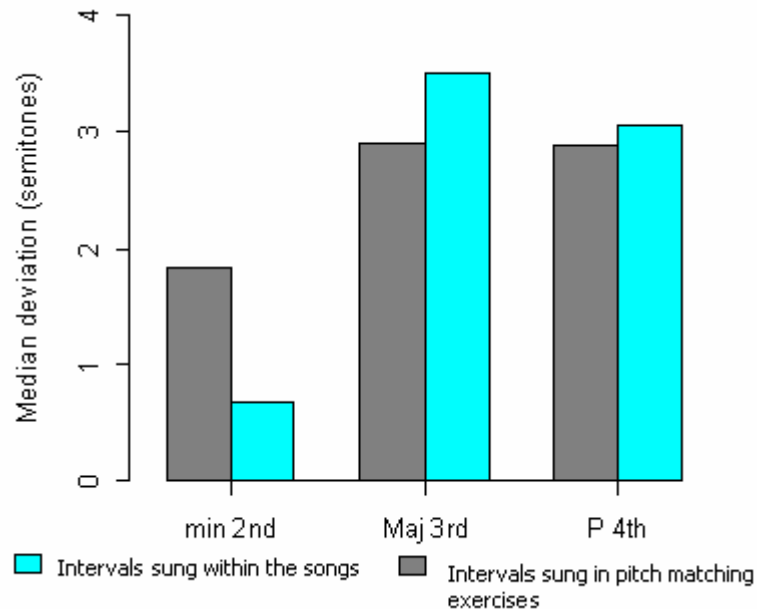
**Figure 65b. Subject E: Contours for selected song phrase**

When the contours of the four sessions were graphed and compared against the target, a progressive improvement in pitch control of the sustained note (for the word *man*) is noticeable (q.2c). During session nine and session 14, subject E was more able to maintain a constant pitch than he was able to in the earlier sessions.

Evidence of improved pitch control is also evident in the gradual development of clearer and more distinctive pitch movements from session one to session 14. For example, during sessions one, six and nine, the change in pitch between the syllables *bet - ter* were characterised by sliding movements where the voice moved through a range of frequencies in the attempt to move from the lower to the higher note. This sliding pattern is most evident in session one, becoming less evident in session six and nine. During session 14, this pattern is replaced with clearer and more distinctive movements between two note pitches.

### ***Comparison between intervals in pitch matching exercises and in songs***

Figure 66 compares the three intervals contained within the song phrase with those produced in the PME.



**Figure 66. Subject E: Accuracy differences between pitch matching exercise and pitch matching in song phrases**

This figure shows that subject E was more accurate in singing the minor 2<sup>nd</sup> interval when placed in a familiar song than when in a PME, a finding also evident for subject C and D. However, the reverse trend emerged for the major 3<sup>rd</sup> or perfect 4<sup>th</sup>. The higher degree of accuracy in the PME for the major 3<sup>rd</sup> and perfect 4<sup>th</sup> might arise from:

- the additional time allowed within the PME for the subject to prepare to sing the intervals, this factor being absent in the continuous flow demanded in the singing of songs
- the required intervals were presented twice in the PME prior to the subject's production of them providing him with a model, and
- the PME presented with an absence of other factors such as rhythm, tempo and text, which might influence singing accuracy.

However, these findings must be viewed with caution because only three intervals were studied in the PMS compared with ten in the PME. Further, the intervals in the song



phrase were small (maximum of perfect 4<sup>th</sup>) whereas in the PME, intervals ranged through to a major 7<sup>th</sup>. A different outcome might emerge had larger intervals been a component of the song phrase material.

### ***Discussion of pitch matching in exercises, songs and other measures***

Results show that there were long term increases in control of pitch during the singing of song phrases but not during the singing of intervals presented in PME (q.2c). Several reasons may explain such differences. First, significant impairments in impulse control, high degree of perseveration, and poor concentration arising out of TBI prevented subject E from performing accurately in the PME (Prigatano, 1999a). These impairments did not affect the largely automatic singing of song phrases to the same degree. Such cognitive problems were evident when subject E:

- sang the interval in an upward rather than downward direction and vice versa to what was required (lack of concentration or poor ability to discriminate higher from lower tones)
- began to sing the interval prior to hearing it in its completion (impulsivity)
- sang the same interval throughout the task rather than the one presented (perseveration).
- commenced singing the interval on the same note as the previous interval (perseveration)

Another explanation stems from the fact that the song phrases contained only small intervals, which were more likely to improve in control and accuracy than larger intervals. As the PMS only included smaller intervals, it was more likely that an overall improvement would occur than if the phrases also contained larger and more difficult intervals, this being the case in the PME.

Results seem to point to a link between increased  $F_0$ , SVS and slope, and increased pitch control in the PMS, but not in PME (q.3c). The results reported earlier showed that the VR of subject E increased from five semitones to eight semitones over the course of the program. This improvement may be attributed to the singing of three songs, which utilized moderately wide pitch ranges (between eight semitones and 14 semitones).

Subject E reported feeling all emotions intensely, including the polarities of happy-sad, and tired-energetic. Increased feelings of anger and fear were reported post-session and long term. Feelings of fatigue also increased long term. Conflicts between the thematic

material and the musical parameters of two of these songs might explain why the subject responded in such a confused manner. For example, *Cecilia* is a song about the loss of a love relationship, however this theme is portrayed through the musical parameters, which would typically convey happiness – fast tempo and a major key. The other example is the song *Better man* where the lyrics convey tension between a man and a woman. However the tempo is slow and there is a predominating minor 3<sup>rd</sup> interval which is centred in a major key, these not evoking feelings of tension. Such differences may explain why subject E might experience simultaneous feelings of sadness and happiness, tiredness and energy. Increased feelings of anger and fear post-session and longer-term might have been evoked from the thematic content of these songs which explore issues of death and dieing, tension in relationships and loss of a love relationship. Perhaps subject E was responding to these themes given that these songs could potentially relate to his post-trauma situation. This idea is speculative as subject E was never questioned about his thoughts and feelings concerning these issues.

#### **5.7.5 Post-treatment assessment of pitch discrimination**

At the completion of the treatment program, subject E was asked to repeat two of the exercises included in the pre-selection tasks to determine whether there were further improvements in his pitch discrimination and intonation discrimination abilities. The post-treatment re-assessment indicated that subject E decreased his accuracy in pitch discrimination from 60% to 50% and increased his accuracy in affective intonation discrimination from 40% to 60%.

To determine whether subject E perceived changes in his vocal expressive potential, he was asked to indicate on a post-treatment questionnaire whether he perceived any improvements in his voice post-treatment. The results indicate that subject E perceived a slight improvement in his voice overall, and a slight improvement in both his expression of emphasis and emotion.

#### **5.7.6 Summary and conclusions**

Results of the 15-session music therapy program showed that singing songs had a positive effect on the expressive speaking potential of subject E (q.1). Long term increases in SVS and slope indicate that subject E was able to express himself more dynamically and

expressively (q.4). However, when compared with the non-clinical sample, it is clear that subject E continues to have substantial difficulty in this area and further treatment is recommended. The largest increases were noted in the  $F_0$ . This was regarded as important given that family had reported a decrease in his speaking  $F_0$  post-injury. Further, subject E showed an increased ability to use SVS and slope to differentiate between different feeling states (q.4). Immediate effects of treatment were not obvious, with small and inconsistent differences found between the pre- and post-session responses.

Findings presented showed that the VR of subject E increased over the course of the program, particularly at the pre-session and this was directly linked with increases in the sentence measures (q.2a, q.3a). As for mood states, subject E often reported polarities in mood responses but generally assigned high values to most feeling states (q.2b). Over time, subject E reported increases in anger, fear and tiredness. Inconsistencies in the relationships between mood changes and changes to sentence measures were evident for subject E and no conclusions can be drawn from the data (q.3b).

Improvement in interval reproduction and pitch control during singing corresponded with increases in the sentence measures (q.3c). This suggests that singing songs was a beneficial treatment for subject E with regard to increasing his expressive potential. A reverse trend was noticed for the PME, this lack of relationship being explained by subject E's inability to participate to his maximum potential due to problems with impulse control, perseveration and poor concentration (q.3c).

In conclusion, subject E was responsive to the singing program and showed improvements in his speaking voice over the course of the 15 sessions. Further, these improvements appeared to be linked with increases in VR and pitch control in singing (PMS).

## CHAPTER 6

### RESULTS OF POOLED DATA

This chapter describes the results when all the subjects' raw data were pooled together and analysed. The study was not designed to compare between subjects or to establish generalisability, however, the pooled results were calculated to determine whether any patterns emerged in the data.

To assist the reader in understanding the results, their presentation follows the same order found in the case studies. First, effect size calculations and between-subject differences for the sentence tasks are presented. The effect sizes relating to VR changes are then presented alongside the visual presentation of each individual subject's changes over time. This leads into the presentation and brief discussion of a correlation analysis between the VR and sentence data to investigate possible relationships. Following this, the effect sizes relating to the mood scale scores are detailed. Results and a discussion of a correlation analysis between the mood scale data and the sentence data are used to illustrate relationships that may exist between these measures. The results chapter then presents a section relating to the subjects' responses in the PME and PMS. Such results include a visual presentation of the between-subject differences, between-interval differences, and a comparison of subject responses between the PME and the PMS. This section concludes with a discussion of subject similarities and differences in response.

#### 6.1 Sentence measures

##### 6.1.1 Between-subject differences in sentence measures

To highlight between-subject differences across all four sentences, the following section compares and discusses the subjects' response patterns.<sup>27</sup>

##### *Fundamental frequency*

Figure 67 illustrates the immediate and long term effects of treatment on the  $F_0$  for each of the four subjects (q.1).

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<sup>27</sup> Note that the forthcoming figures are reported earlier in the individual case studies but are restated here to assist the reader in following the comparative differences between subjects.

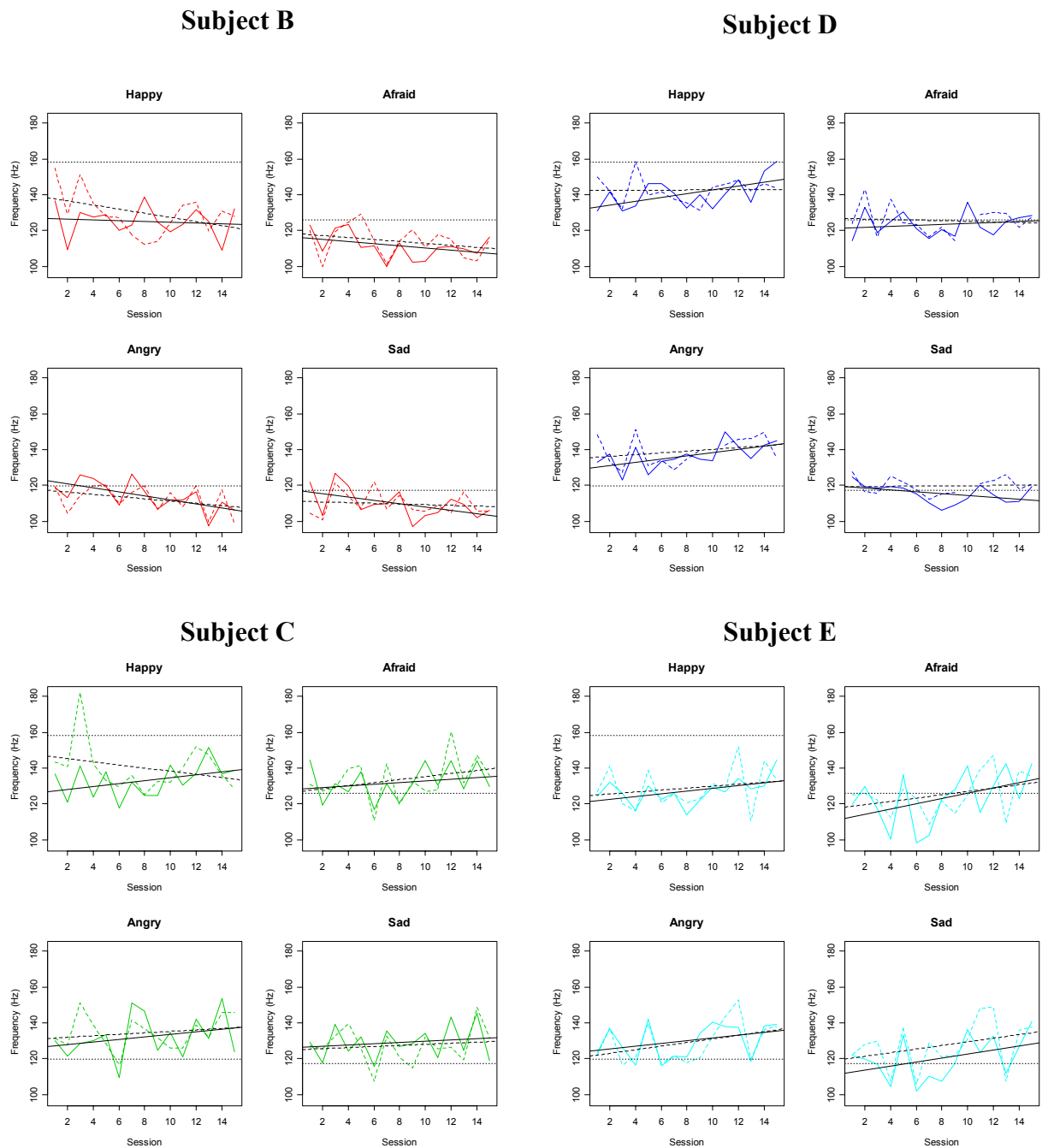


Figure 67. Subject differences in fundamental frequency data

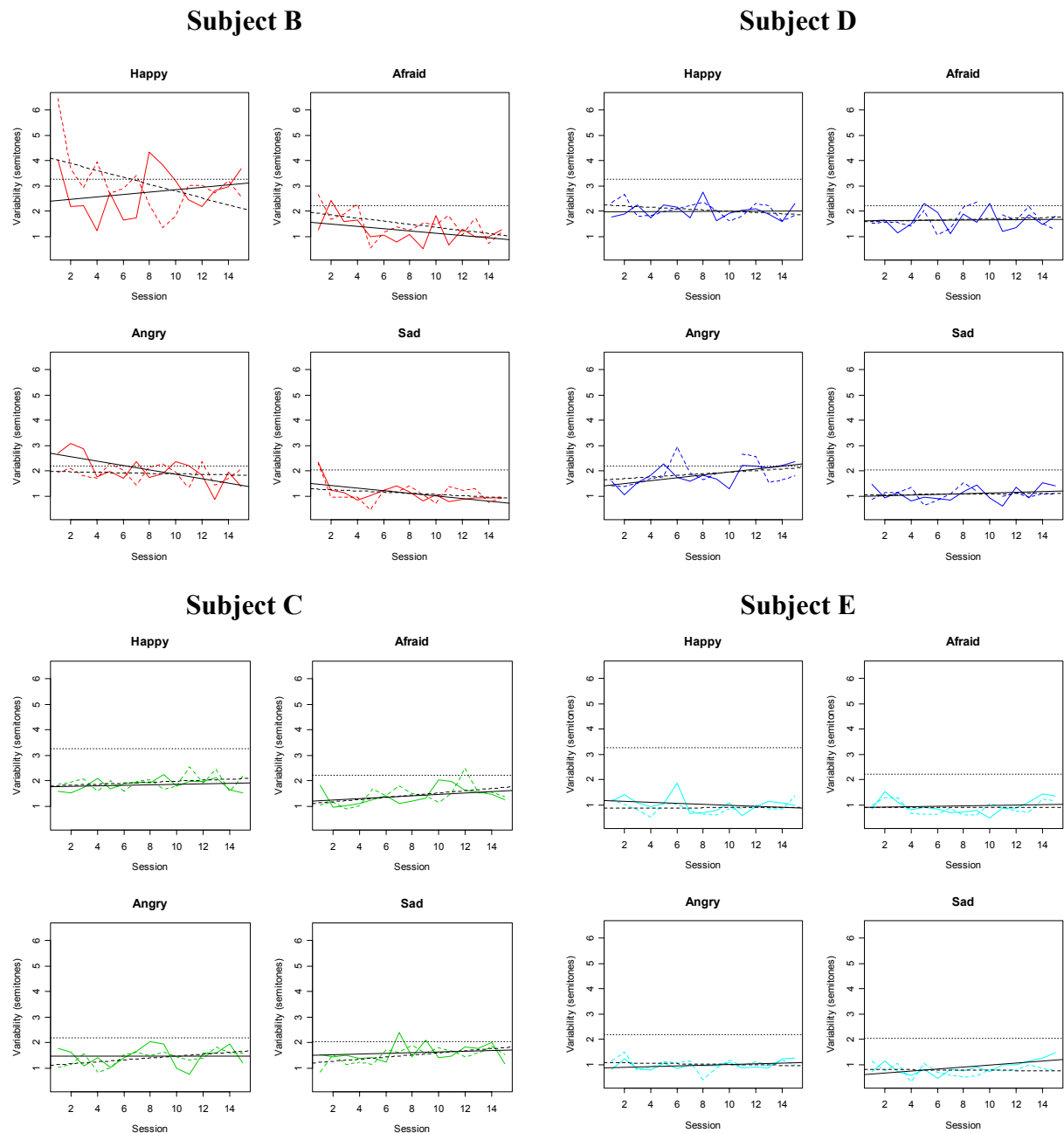
Figure 67 shows the subject differences in  $F_0$  with respect to immediate changes (pre/post) and long term changes. Apart from subject B, who's  $F_0$  decreased over time, the figure shows that the  $F_0$  for all sentences increased over time for all subjects. It is also evident that the degree of response and its direction had some similarities between subjects especially for angry where the degree of increase in  $F_0$  is similar for subject C, subject D and subject E. It can be seen from this figure that subject E was the most responsive to treatment with large increases in  $F_0$  over time for all sentences. Responses across subjects showed that the variability (consistency) in  $F_0$  was large, with subject E displaying the highest variability and subject D the lowest variability. Consistent across all subjects was the finding that the pre-session scores were generally higher than the post-session scores, with these differences decreasing in size over the course of the program (cumulative effects).

With regard to the subjects' expressive potential, subject D increased his differentiation between the four sentences to the greatest degree. Subject C also increased his differentiation between the different sentences however he also displayed high variability and low consistency in his responses. Subject B and E did not increase their differentiation between the mood sentences.

Initially, the  $F_0$  measures for all subjects for the sentence expressing anger was equivalent to or higher than the measures for the non-clinical sample. Subjects C, D and E further elevated their  $F_0$  when expressing anger over the course of treatment. Subject C demonstrated  $F_0$ 's above the non-clinical sample for all sentences except for happy. The  $F_0$  for happy was lower than the non-clinical sample for all subjects.

### ***Standardised variability score***

Figure 68 below illustrates the immediate and long term effects of treatment for each of the four subjects with regard to their SVS (q.1).



**Figure 68. Subject differences in standardised variability scores**

By viewing the data in Figure 68, it is evident that the degree of response and its direction differed between subjects and between sentences. Subject E displayed the lowest SVS (that is, was the most monotonal) and the smallest variation in SVS between the different affective sentences indicating that he had the most difficulty in inflecting different emotions into his voice. He also showed the least change over time. As consistent with the  $F_0$  data, and discussed previously, subject B was the only subject whose SVS decreased

over time. The long term increases in SVS for subject C and subject D were similar in degree. Inconsistent long term response patterns can be seen in the SVS for happy where scores decreased slightly for subject D and E and increased slightly in Subject C.

Immediate effects of treatment also varied between subjects and between the different sentences, with no consistent pattern of immediate changes to SVS evident.

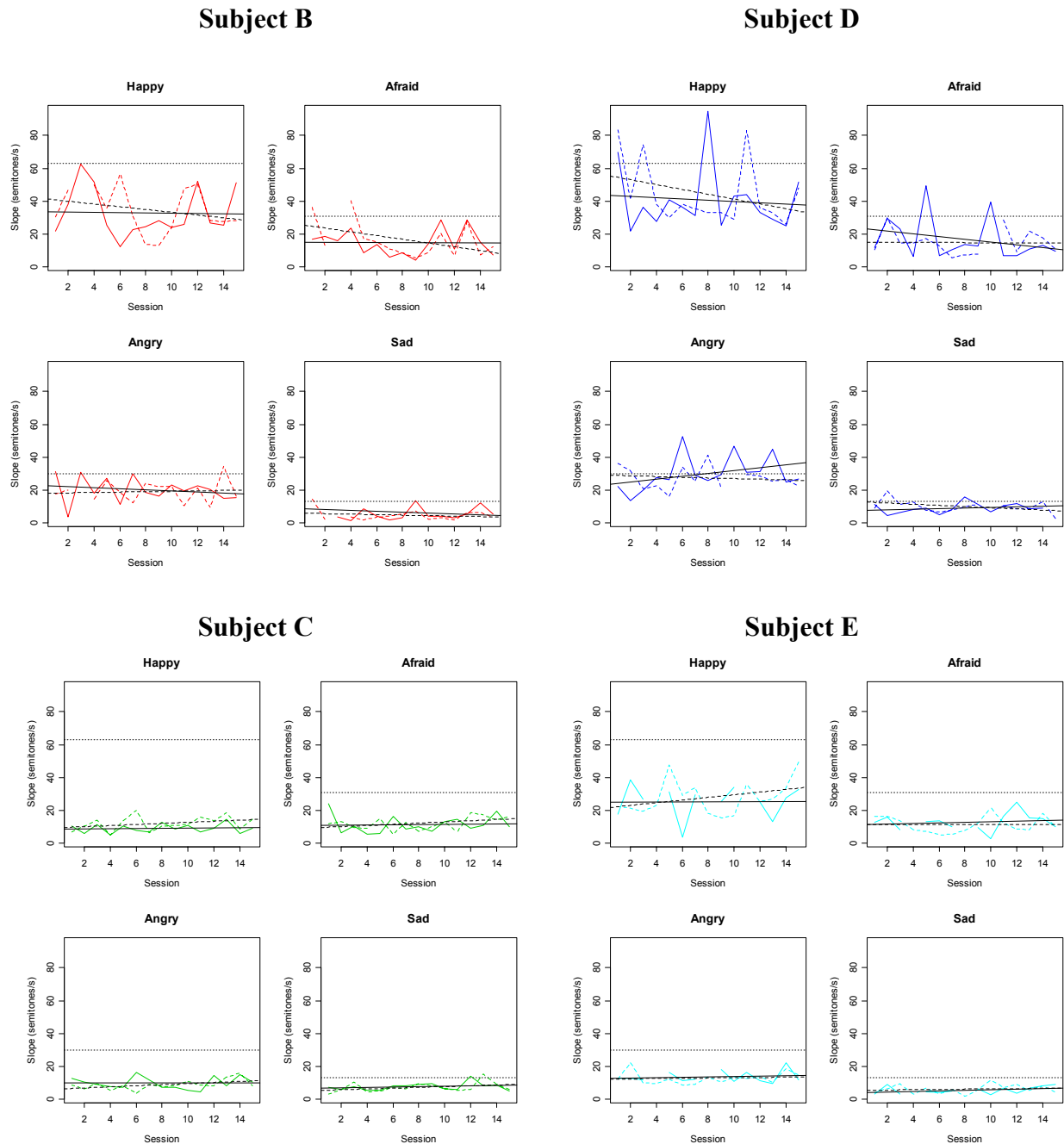
Compared with the non-clinical sample, subject B's SVS became more limited over the course of the treatment whereas subjects C and D (and to a smaller extent, subject E) enlarged their SVS so that their responses were more expressive and moved slightly closer toward the responses given by subjects in the non-clinical sample.

It can be concluded that with the exception of subject B, long term increases in the SVS were observed as a consequence of participating in the treatment. No immediate effects of treatment were observed although there was some evidence that long term positive immediate effects were emerging. It can also be concluded that despite increases in SVS in some subjects, all subjects remained substantially impaired in using SVS in their voices when compared with the non-clinical sample. Subject D was the only subject who became noticeably more able to manipulate differing levels of SVS so as to differentiate between emotions.

### ***Slope***

Figure 69 illustrates the immediate and long term effects of treatment for each of the four subjects with regard to their slope production in the four-sentence tasks (q.1).





**Figure 69. Subject differences in slope data**

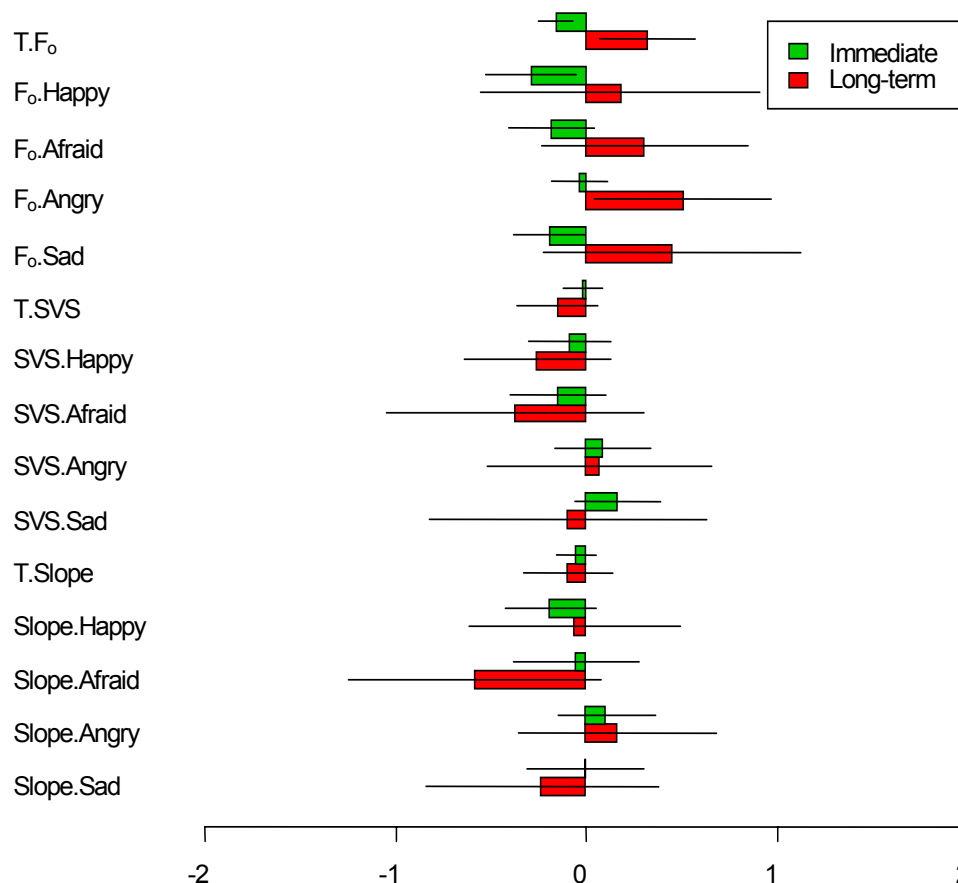
Figure 69 shows that slope was the least affected component of intonation influenced by the treatment. It also shows clear differences in the use of slope between the different subjects with subjects B and D differentiating between mood to a large degree through the use of slope, and subjects C and E not doing so. Both subject C and E made improvements, but their slope measures remained well below the non-clinical sample. This figure also illustrates the large variability in scores for subjects B and D as shown in the

frequently occurring sharp peaks and troughs in the raw data. Trend lines for subject B and D should therefore be interpreted with caution given the high variability in scores displayed by these two subjects.

### 6.1.2 Effect sizes of sentence measures

The effect sizes of the immediate and long term effects of treatment were calculated for the pooled data and are presented in Figure 70. The size of the effects for the  $F_o$ , SVS and slope were calculated in two ways:

- from pre-test to post-test (across all sessions for all subjects);
- from the beginning of the program (using data from the first two sessions for all subjects) to the end of the program (using data from the last two sessions for all subjects).



*Note.* Positive effect sizes represent increases over time. The variables T. $F_o$ , T.SVS, and T.Slope represent the total  $F_o$ , SVS, and Slope, respectively, using data from all the sentences. Horizontal lines represent 95% confidence intervals.

**Figure 70. Effect sizes for sentence measures**

Figure 70 shows that overall, the long term effects tended to be larger than immediate effects (q.1). The  $F_o$  in all sentences showed slight decreases immediately after the session (immediate effects), but larger increases in the longer term. Both the immediate and the long term changes in  $F_o$ , when taken together from all sentences (T. $F_o$ ), were significant ( $p < .05$ ) indicated by the confidence interval not crossing the point zero (the data showing the effect size scores calculated in these statistical analyses are tabulated in Appendix 10.24). Effect sizes for the SVS and slope varied between the sentences and no consistent patterns emerged.

As observed in the graphs representing the individual subject's responses to treatment (Figure 67, 68, and 69), subject B's long term trends which were in the direction contrary to the other subjects, strongly contributed to the negative effect sizes calculated and shown here. Further, the tendency for some subjects in some places, to over-exaggerate the intonation of the sentences in the initial sessions also contributed to the long term negative effects illustrated here (subject B, D and E).

### 6.1.3 Discussion on sentence measures

These results indicate that the treatment had the most impact on the  $F_o$ , particularly for the expression of anger, where the effect size was large and significant (q.1). Further, the long term effect sizes were moderate and significant for the pooled  $F_o$  data. The results also showed that the SVS scores increased in some subjects but not others. Visual inspection of the slope data revealed no distinct patterns across subjects with high variability in scores resulting. Despite some significant results found in effects over time, overall,  $p$ -values for effect sizes were low across the board with only a few significant findings emerging.

These analyses should be interpreted with caution because individual subject differences may have skewed the pooled results in either a positive or negative direction. For example, subject B's responses which moved in a negative direction long term would have highly influenced the effect size calculations. Large between-subject differences were also found by Cohen (1992, 1995). When such large between- and within-subject differences are evident, a larger number of subjects are required to pool results reliably.

Emerging from these results are some common immediate and long term responses to treatment. For the immediate effects, it was commonly reported that pre-session measures were larger than post-session measures, indicating that the effect of treatment

was contrary to that suggested by the literature (Haneishi, 2001). This pattern was evident for all three measures, particularly that of the  $F_0$ . Further, for many of the sets of data, these pre/post-session differences became smaller over time suggestive of cumulative effects of treatment. Possible reasons for this trend might be that subjects need to become familiar with the treatment before the treatment can take effect. The importance of familiarity of treatment has been raised by Wigram (1993) and will be further discussed in Chapter 7 (7.1.1).

The conclusion of these analyses is that the treatment was effective in enhancing intonation variables in some subjects but not in others and for some intonation variables but not others. The subjects' response patterns were highly individualised and there were no generalisable patterns emerging from the data.

## 6.2 Vocal range

One of the questions posed in this study was whether immediate or long term increases in VR occurred as a consequence of the treatment program (q.2a) and if so, whether these increases could be argued as influencing the intonation variables (q.3a). This next section reports and discusses on the data analyses pertaining to these issues and is divided into five sections: descriptive data of the effects of treatment, effect sizes for the immediate and long term effects of treatment, figures describing between-subject differences in changes to VR, correlations between VR and sentence measures, and a brief discussion of the findings.

### 6.2.1 Descriptive statistics of the effects of treatment

Table 23 presents the mean number of semitones and the corresponding standard deviations for the immediate (all pre- and post-session data points) and long term effects (data points from sessions 1-2 and 4-15) of treatment on the VR.

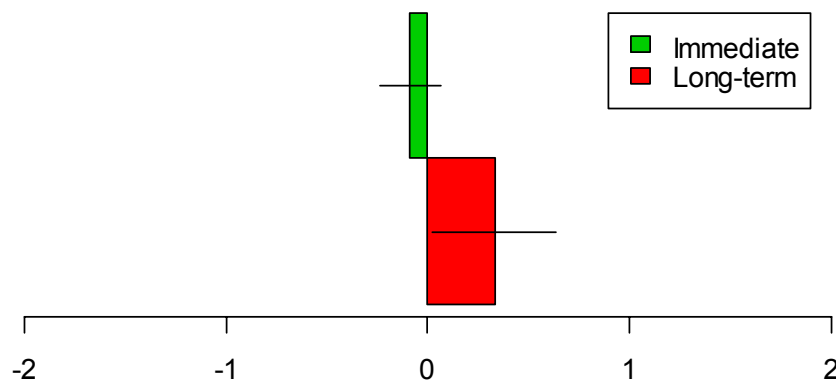
**Table 23. Immediate and long term effects of treatment on vocal range**

| <i>Long term Effects</i> | <i>n</i> | <i>M</i> | <i>SD</i> | <i>Immediate Effects</i> | <i>n</i> | <i>M</i> | <i>SD</i> |
|--------------------------|----------|----------|-----------|--------------------------|----------|----------|-----------|
| Sessions 1-2             | 15       | 9.192    | 4.612     | Pre-session              | 59       | 11.461   | 4.791     |
| Sessions 14-15           | 16       | 10.985   | 5.161     | Post Session             | 59       | 11.077   | 5.411     |
| Difference               |          | 1.793    |           | Difference               |          | -0.384   |           |

Table 23 shows that the mean long term increase in VR was 1.793 semitones, whereas there was a mean decrease in VR of 0.384 from pre- to post-session. The degree and directions of these effects for each subject are described in Figure 72.

### 6.2.2 Effect sizes of vocal range data

To establish the size of both immediate and long term effects of treatment, effect sizes were calculated as previously described for the sentence data. The results are presented in Figure 71.



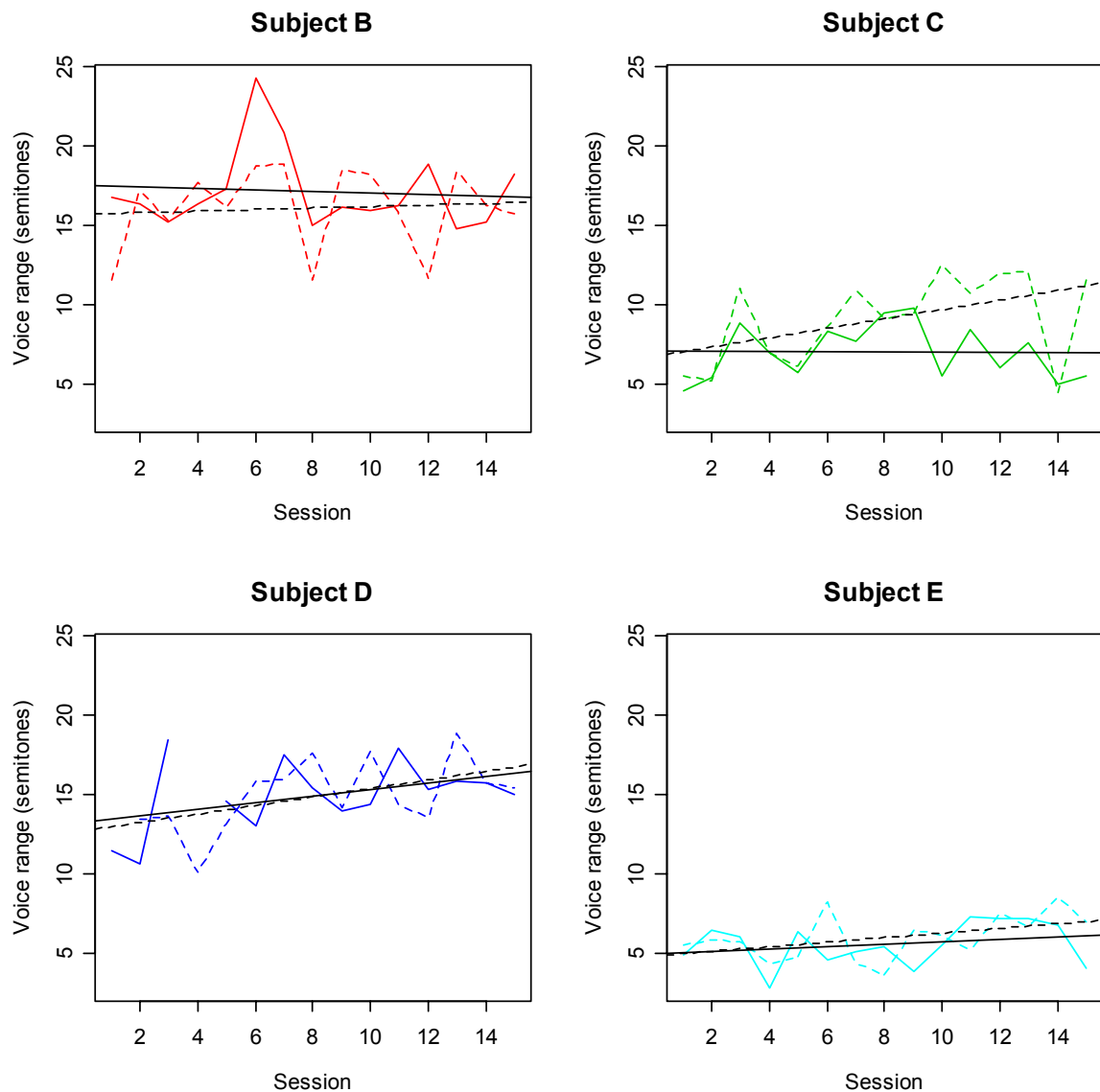
*Note.* Horizontal lines represent 95% confidence intervals.

**Figure 71. Effect sizes for vocal range data**

This analysis shows that the treatment had a significant long term effect ( $p < .05$ ) on VR. Here, the difference in VR between the first two and last two sessions was large when all subjects' raw data scores were pooled. While all four subjects showed increases in VR, this significant outcome is attributed to Subject D's large long term increase (Figure 72). The effect sizes for the immediate treatment effects were not significant. Data showing the exact numerical scores calculated in these statistical analyses are tabulated in Appendix 10.24.

### 6.2.3 Between-subject differences in vocal range data

The individual response trends in VR for each subject are illustrated in Figure 72.



**Figure 72. Between-subject differences in vocal range**

Figure 72 illustrates the idiosyncratic nature of subjects' immediate and long term response patterns. It highlights that subject B and E displayed little apparent change in their VR overall when compared with subject C and D, although these increases are still regarded as clinically significant as discussed in the individual case studies. Subject B displayed the highest VR in the first instance, with subject E displaying the lowest VR. Subject C and E displayed immediate effects of treatment contrary to that hypothesised particularly towards the end of therapy as evidenced by the pre-session trend lines being higher than the post-sessions trend lines. This was more evident for subject C than subject

E. Subject D displayed the largest long term effect for both his pre- and post-session responses, and the smallest immediate effects of treatment.

#### 6.2.4 Correlations between vocal range and sentence measures

Correlations between VR and the  $F_o$ , SVS and slope were calculated using the Pearson's Product Moment Correlation Coefficient in order to establish whether there was a relationship between size of VR and any of the three intonation measures (q.3a). The results of this analysis are presented in Table 24.

**Table 24. Correlations between vocal range and sentence measures**

| <i>Sentence</i> | <i>r(F<sub>o</sub>,VR)</i> | <i>r(SVS,VR)</i> | <i>r (slope,VR)</i> |
|-----------------|----------------------------|------------------|---------------------|
| Happy           | .06                        | <b>0.58***</b>   | <b>0.42***</b>      |
| Afraid          | <b>-.39***</b>             | <b>0.32***</b>   | 0.18                |
| Angry           | <b>-.28**</b>              | <b>0.66***</b>   | <b>0.53***</b>      |
| Sad             | <b>-.51***</b>             | 0.00             | 0.06                |

*Note.* Significance codes: \*\*\*  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$

Table 24 shows that VR tended to be negatively correlated with the  $F_o$ , indicating that as the VR increases, the  $F_o$  decreases. Conversely, the correlation analyses revealed that increased VR correlates positively with slope and SVS indicating that as VR increases, variability and slope also increase.

#### 6.2.5 Discussion of vocal range and sentence data

The findings presented in the effect size calculations showed that there were significant long term effects of treatment on the VR of subjects in this study, although the size of the effect of treatment varied between subjects (Figure 72) (q.2a). There were no consistent patterns in the immediate effects of treatment observed. Given that the initial maximum VR of these subjects was small, particularly in subject C and subject E (Figure 72), this finding is important given that a limited maximum vocal range may affect intonation (q.2a).

When these improvements were correlated with the intonation parameters, positive correlations were found between increases in VR and increases in SVS and slope. This suggests that there is a direct link between increases in vocal range and increases in speaking expressivity as a consequence of the treatment (q.3a). However, a negative correlation was established between VR and the  $F_0$  (q.3a). From a physiological perspective, the behaviour of the vocal cord muscles and their consequential influence on intonation parameters, may explain both the positive and negative correlations. First, a lower  $F_0$  signifies a relaxed voice, indicating an overall lower level of tension (Aronson, 1990). Second, lower levels of tension result in greater flexibility of the vocal folds and therefore greater range and greater possibilities for increased SVS (Leonard et al., 1988). A more detailed discussion of this idea is presented in Chapter 7 (7.1.3).

### 6.3 Mood scale data

Two of the questions posed in this research study concern the mood scale data as assessed by the VAMS. The first question asked whether the therapy treatment had an immediate and a long term effect on the subjects' self-reported mood (q.2b). The second question asked whether changes in self-reported mood were correlated with changes in the intonation parameters analysed in the sentence tasks (q.3b). To answer these questions, the pooled results from the VAMS were used to calculate the size of the effect of treatment for each mood assessed and the results of these are reported in 6.3.1. This section then concludes with the presentation and discussion of correlations calculated between the sentence measures and the mood scale measures (6.3.2 and 6.3.3).

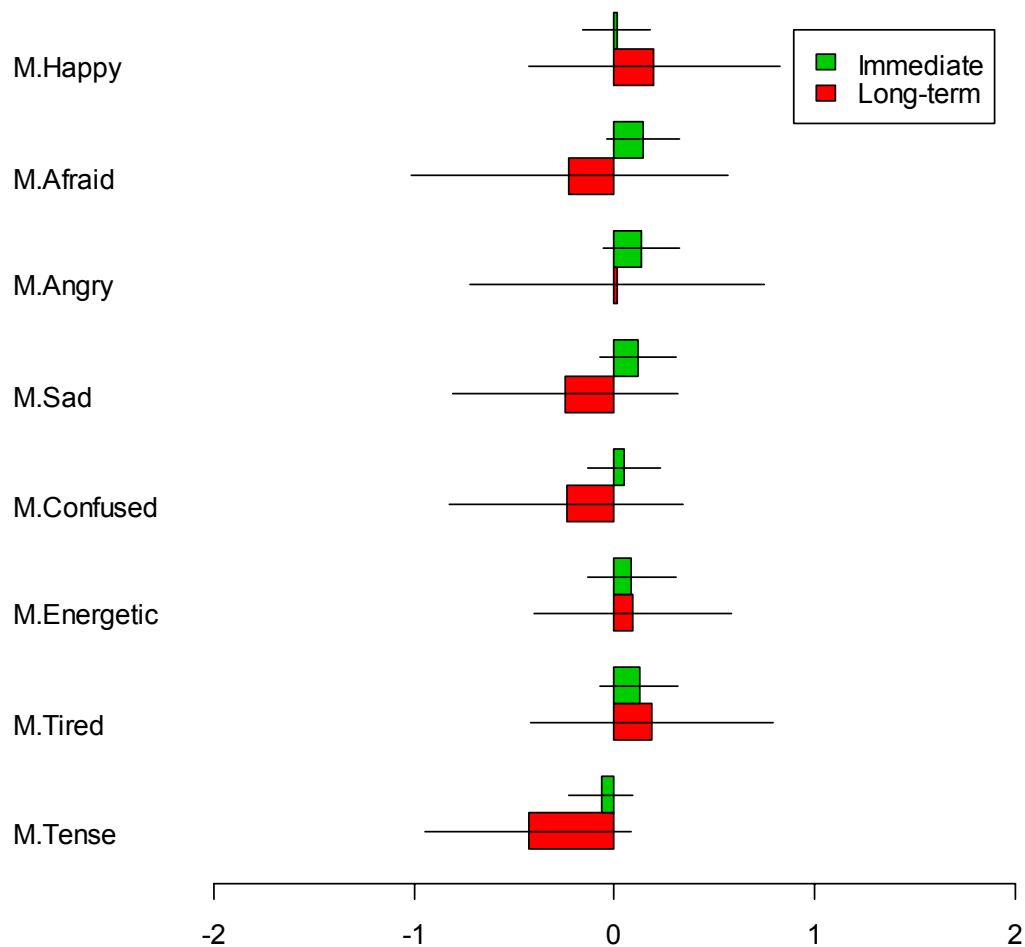
#### 6.3.1 Effect sizes for mood scale responses

To determine the size of the immediate and long term changes to mood, effect sizes were calculated using the procedure described previously.<sup>28</sup> These results are illustrated in Figure 73 (the data showing the exact numerical scores calculated in this statistical analysis are tabulated in Appendix 10.24). In this figure, a negative effect size signifies a reduction in the reported mood (a greater flattening of affect).

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<sup>28</sup> Immediate effects were calculated using the pooled pre- and post-session measures across all sessions whereas the long term effect sizes were calculated using the pre- and post-session measures for the first two and last two sessions.





*Note.* Horizontal lines represent 95% confidence intervals.

**Figure 73. Effect sizes for the visual analog mood scale**

The effect sizes in this figure illustrate some trends, but there were no statistically significant effects. More specifically:

- Long term effects tended to be larger than immediate effects.
- Immediate effects show that scores for most emotions increased post-session (subjects reported increased affect). In particular, subjects reported experiencing greater feelings of fear, anger, and sadness.
- conversely, long term effects seem to suggest that subjects reported experiencing becoming happier, less afraid, less sad, less confused, and less tense.
- feelings of tiredness tended to increase both in the immediate and long term context.

However, due to the unusual distributions of values, and therefore an increased estimate of the standard deviation, the effect sizes reported here are likely to be an

underestimation of the true effect sizes. Therefore, these results should be interpreted with caution.

### 6.3.3 Correlations between mood scales and sentence measures

To explore any potential relationship between reported mood change and the intonation measures of the  $F_0$ , SVS, and slope, correlations between the VAMS and the three intonation measures were calculated using the Pearson's Product Moment Correlation Coefficient (q.3b). The results of the analyses are presented in Table 25. It is worth mentioning again here that not all correlations between the four sentences and the eight moods were calculated. The researcher chose only to correlate those moods where a possible relationship was hypothesised. For example, the analyses tested for a relationship between the happy VAMS (row two, column one) and the happy sentence (row two, column two) but not with the other three sentences (angry, sad, and afraid).

**Table 25. Correlations of mood scales and sentence measures**

| <i>Mood scale</i> | <i>Sentence</i> | <i>F<sub>0</sub> (r)</i> | <i>p</i>  | <i>SVS (r)</i> | <i>p</i>  | <i>Slope (r)</i> | <i>p</i>  |
|-------------------|-----------------|--------------------------|-----------|----------------|-----------|------------------|-----------|
| happy             | happy           | -.42                     | < .001*** | -.15           |           | .05              |           |
| afraid            | afraid          | -.01                     |           | -.46           | < .001*** | -.11             |           |
| angry             | angry           | .04                      |           | -.44           | < .001*** | -.25             | < .01**   |
| sad               | sad             | .10                      |           | -.33           | < .001*** | -.19             | < .05*    |
| confused          | afraid          | -.07                     |           | -.40           | < .001*** | -.05             |           |
| energetic         | happy           | -.45                     | < .001*** | -.11           |           | .01              |           |
|                   | sad             | -.29                     | < .01**   | -.44           | < .001*** | -.30             | < .001*** |
| tired             | happy           | -.24                     | < .01**   | -.45           | < .001*** | .07              |           |
|                   | afraid          | -.14                     |           | -.43           | < .001*** | -.18             |           |
|                   | angry           | -.01                     |           | -.38           | < .001*** | -.12             |           |
|                   | sad             | .06                      |           | -.37           | < .001*** | -.16             |           |
| tense             | afraid          | -.09                     |           | -.47           | < .001*** | -.09             |           |
|                   | angry           | -.04                     |           | -.54           | < .001*** | -.25             | < .01**   |

*Note.* Significance codes: \*\*\*  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$

The results in this table show many negative correlations, especially correlations with the SVS, which were highly significant in all cases except two (happy VAMS with happy SVS; energetic VAMS with happy SVS). This means, when high scores on a VAMS were recorded by the subjects (increase affect), they tended to say the sentence describing this mood (or a related mood) in a more monotonal way, with less variability in the

frequency of their voice. However, there is one inconsistency evident in these findings with regard to opposing moods of energetic and tired. Findings suggest that as subjects became more energetic, they became more monotonal in their SVS, lower in their  $F_0$  and displayed flatter slopes. However, when subjects also reported experiencing increases in feelings of tiredness, the effects were the same - they displayed lower  $F_0$ , lower SVS, and flatter slope.

### **6.3.3 Discussion of mood and sentence measures**

The results reported here suggest that the treatment program tended to affect some moods of subjects in similar ways (q.2b). Findings highlighted that in the long term, subjects became more happy, less afraid, less sad, less confused and less tense. These are regarded as positive outcomes both for the subjects' own personal emotional state, but also the positive impact they have on their ability to participate in therapy. Such effects and their corresponding clinical implications will be discussed in Chapter 7 (7.1.3; 7.3.2).

Immediate effects on mood did not reveal positive changes with subjects reporting being more afraid, more angry, and more sad (q.2a). Of particular interest is the finding that subjects became more tired in response to the treatment both in the immediate and long term context, fatigue being a commonly reported symptom associated with TBI (Oddy et al., 1985). The issue of fatigue and the clinical implications it places on therapy participation and intonation will be discussed in Chapter 7 (7.3.2).

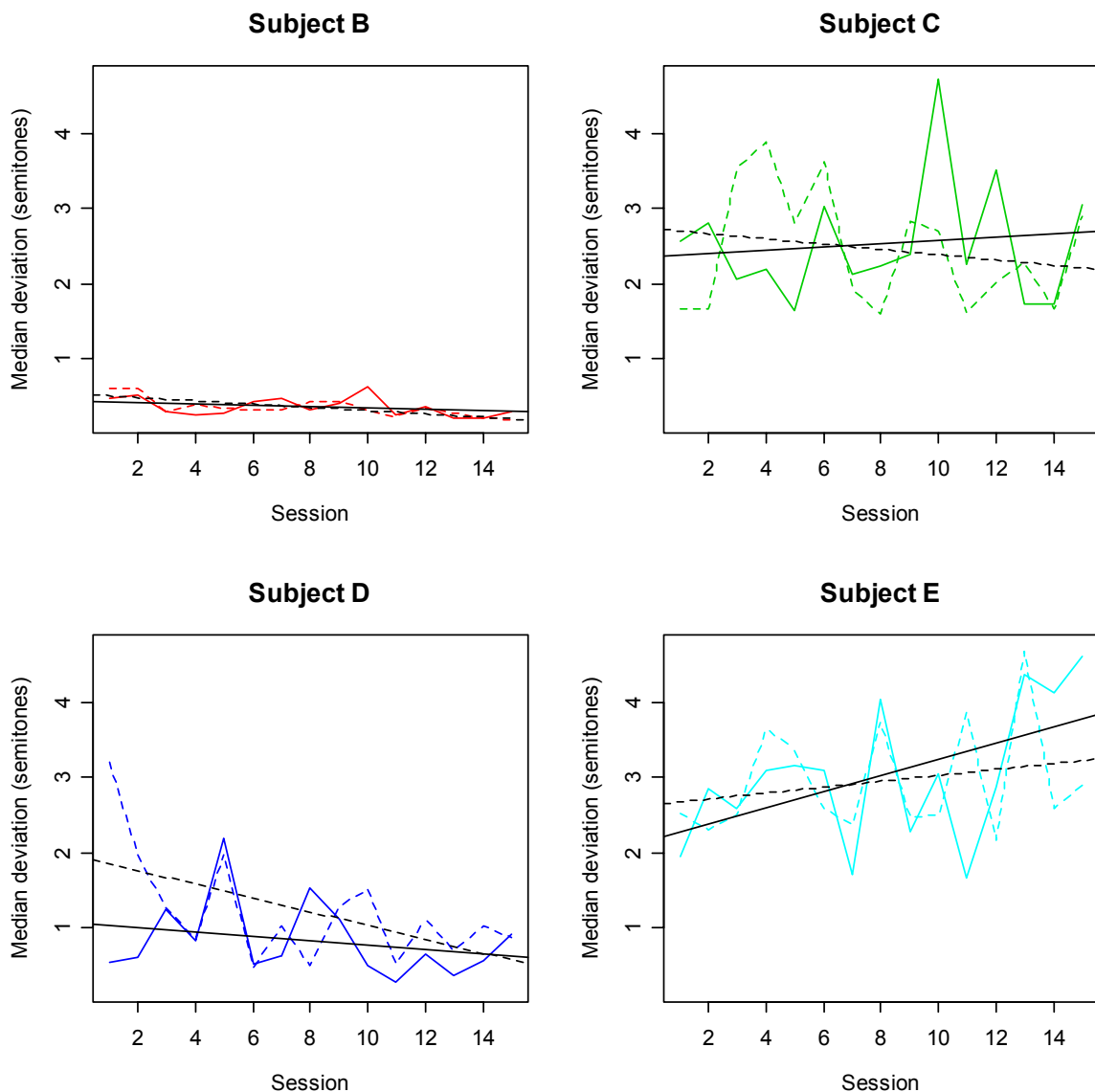
## **6.4 Development of pitch control**

The next section of the results reports on subjects' development of pitch control and is divided into four main sub-sections: a report on the material in the PME; a report on the material in the PMS; a comparison between the PME and PMS; and a brief discussion linking the findings together.

### **6.4.1 Between-subject trends in pitch matching exercises**

To illustrate the large between-subject differences in response as produced in the PME, the responses of each subject were plotted on graphs and placed alongside one

another (as seen in Figure 74). These graphs are based on the combined data (all ten intervals for each subject) at any given time point in the program.<sup>29</sup>



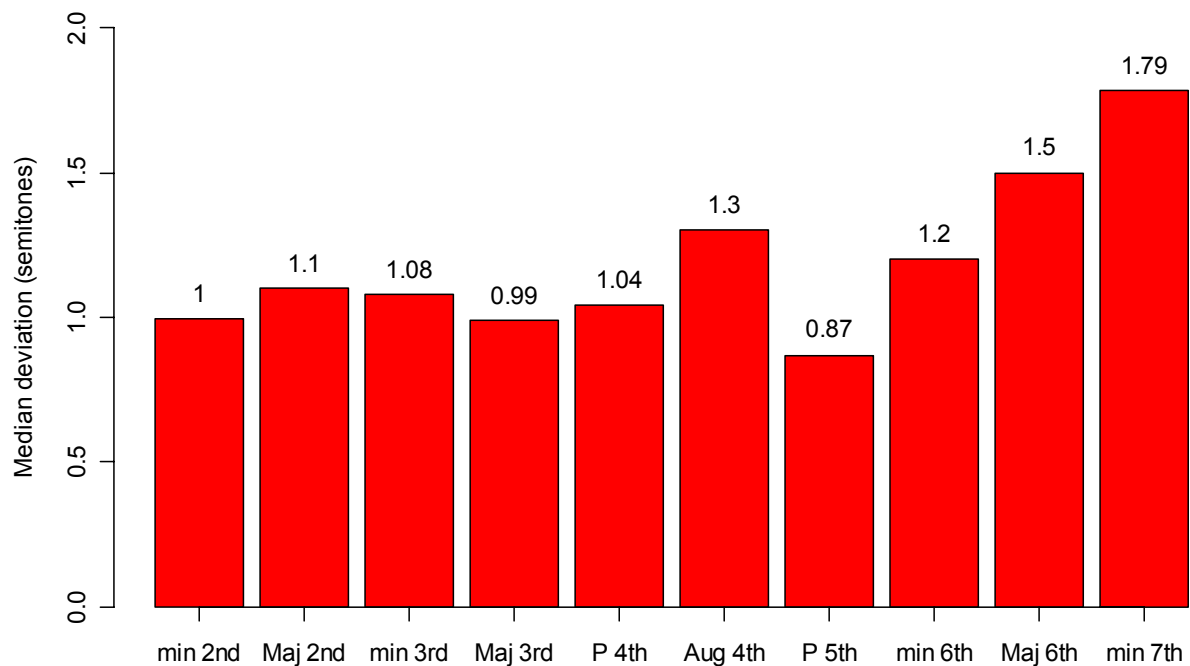
**Figure 74. Subject differences in pitch matching exercise**

Figure 74 shows that subjects differed to a large degree, in the way their accuracy in PME changed immediately post-session and in the longer term (q.2c). The figure shows that subject B was able to pitch match to a highly accurate level from the beginning of the program and also further improved his accuracy in the longer term. He showed minimal pre/post-session differences although the possibility for further improvement at the post-

<sup>29</sup> Because of the skewed distribution of the values, the median of all data was used as the combined score.

session was limited by the fact he was already highly accurate in his production at the pre-session. Subject D showed a tendency to learn quickly at the beginning, with post-session measures typically higher in accuracy than pre-session measures. Subjects C and E had large deviations in accuracy and showed no tendency to improve their pitch matching ability. In conclusion, this figure illustrates the absence of any similarities in response patterns between the subjects.

To illustrate the different degrees of accuracy between intervals, Figure 75 presents the median deviation from the target interval, expressed in semitones, for each interval.<sup>30</sup>



**Figure 75. Differences in accuracy between intervals**

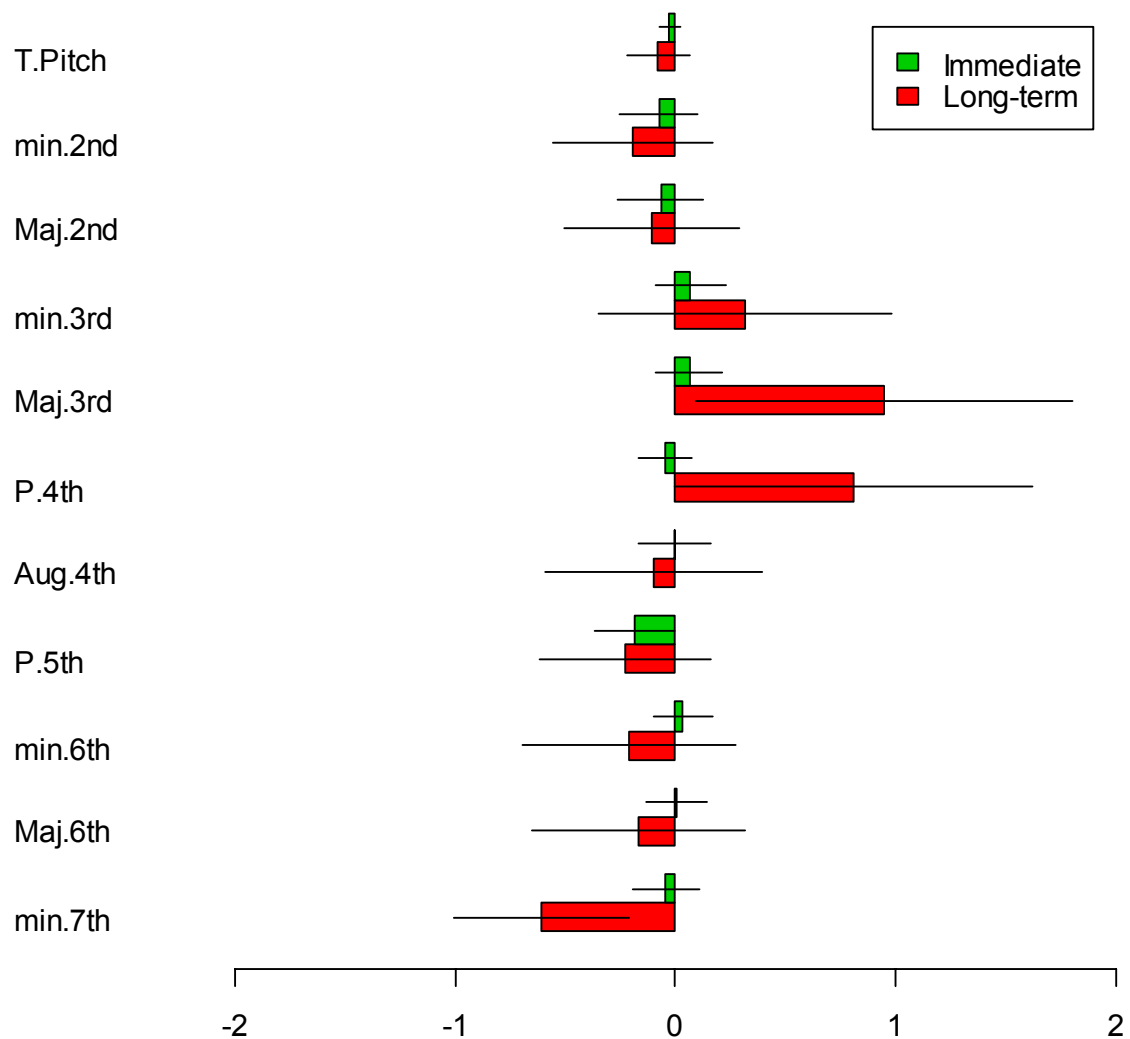
Figure 75 shows that perfect 5<sup>th</sup>, major 3<sup>rd</sup>, and the small intervals were the most accurately reproduced. The greatest deviations from the target interval occurred for larger and more difficult intervals namely the minor 7<sup>th</sup>, major 6<sup>th</sup>, and augmented 4<sup>th</sup>.

To determine the size of immediate and long term changes to the ten different intervals contained in the PME, effect sizes were calculated using the procedure described previously (q.2c).<sup>31</sup> The results are illustrated in Figure 76 (the data showing the exact numerical scores calculated in this statistical analysis are tabulated in Appendix 10.24). In this figure, a negative value indicates an improvement in interval accuracy production

<sup>30</sup> The median was used instead of the mean because of the skewed distribution of this variable.

<sup>31</sup> Immediate effects were calculated using the pooled pre- and post-session measures across all sessions whereas the long term effect sizes were calculated using the pre- and post-session measures for the first two and last two sessions.

whereas a positive value indicates the subject was becoming less accurate in the production of the target interval.

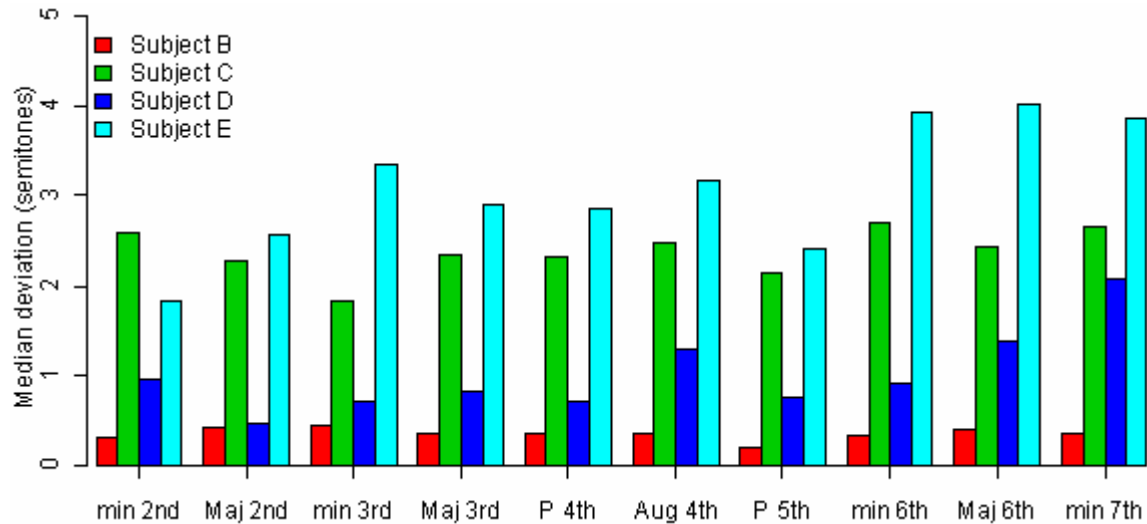


*Note.* Horizontal lines represent 95% confidence intervals.

**Figure 76. Effect sizes for different intervals**

The results from Figure 76 show that there were significant long term improvements in interval accuracy for the minor 7<sup>th</sup> interval. Pitch matching on some of the easy intervals (major 3<sup>rd</sup> and perfect 4<sup>th</sup>) became less accurate over time. Most of the other intervals had a non-significant tendency to become better matched to the presented notes over the course of therapy sessions. However, these effect size calculations should be interpreted with caution because of the skewed distribution described previously.

To establish whether patterns exist between subjects in their accuracy of producing different intervals, Figure 77 plots the median deviation (in semitones) for each of the ten intervals for each subject.

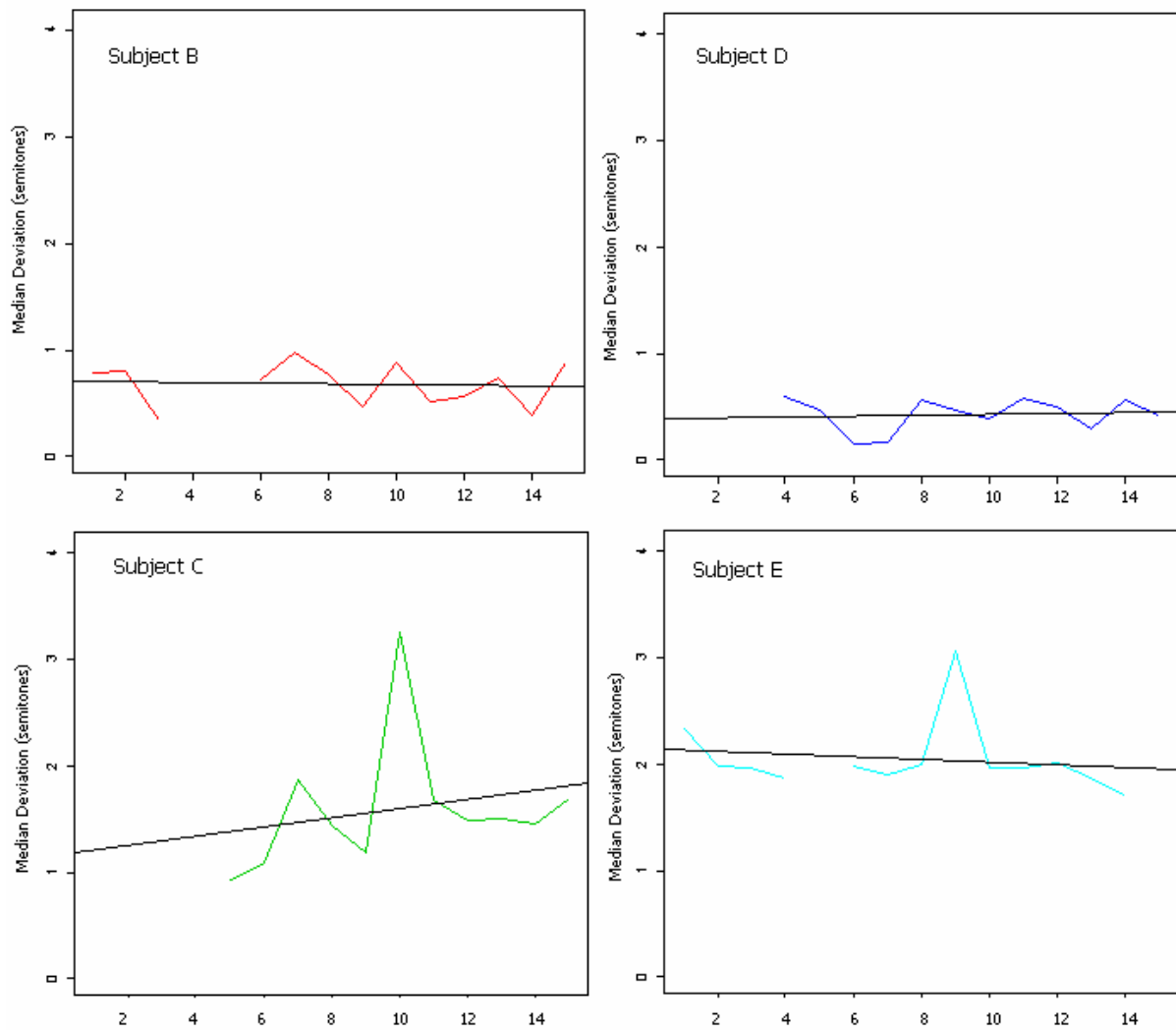


**Figure 77. Subject differences in accuracy across different intervals**

Figure 77 clearly shows that there were large differences between the subjects. Subject B was able to sing all the intervals quite accurately. Subject D was also considerably accurate with most intervals being sung within a semitone deviation. He did however display more difficulty reproducing the larger and more difficult intervals. Subjects C and E had large deviations on all of the intervals.

#### 6.4.2 Pitch matching in song phrases

Figure 78 illustrates the between-subject differences in PMS when all the intervals were pooled and analysed. Again, the median deviation was used instead of the mean due to the skewed distribution of values.



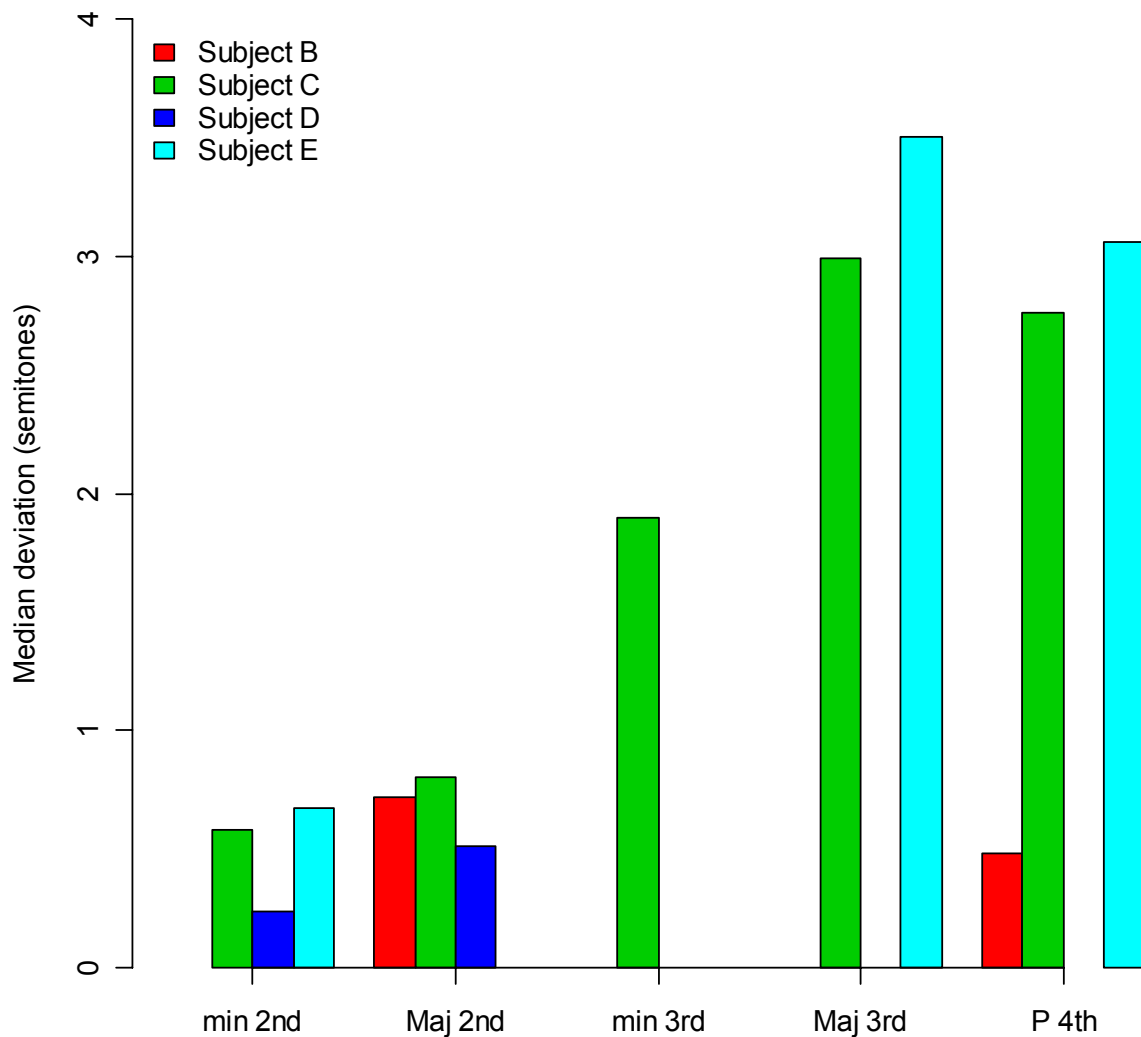
**Figure 78. Trends in between-subject differences in pitch matching in songs**

Figure 78 shows that subject B made slight improvements in accuracy, as did subject E (q.2c). Subject D tended to make no change in his accuracy with a slight tendency towards being less accurate over time. Subject C became less accurate in his production of the song phrases although an outlying value at session ten significantly skewed the trend line.

To establish whether patterns exist between subjects in their accuracy of producing different intervals when presented in song phrases, Figure 79 presents the results where the median deviation (in semitones) for each of the intervals contained in the song phrases is plotted for each subject.<sup>32</sup>

<sup>32</sup> Again, the median was used instead of the mean because of the skewed distribution of this variable.



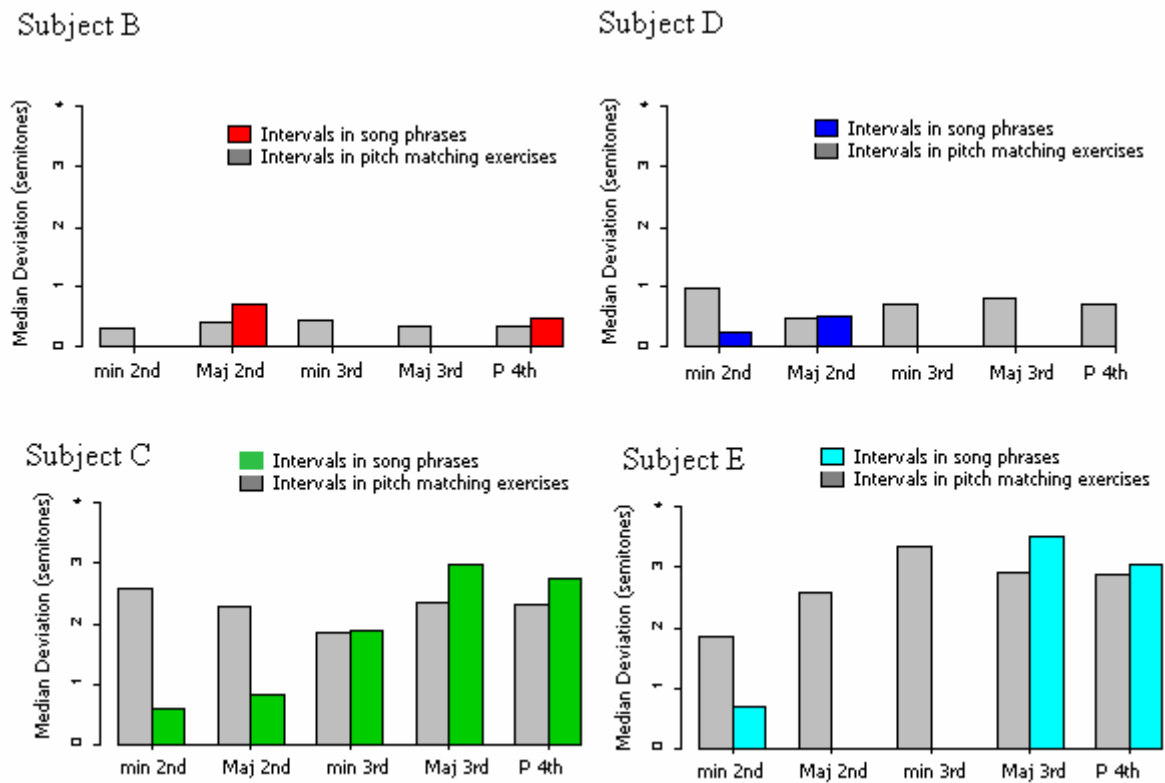


**Figure 79. Subject differences in interval accuracy for song phrases**

As was noted in the PME, this figure highlights that subject C and E were the most inaccurate in the singing of intervals within the song context. Further, the smaller intervals were generally produced more accurately than the larger ones, this difference particularly noteworthy for subjects subject C and E where there were substantial differences in accuracy between the minor 2<sup>nd</sup> and major 2<sup>nd</sup> when compared with the other intervals.

### 6.4.3 Pitch matching in songs and in exercises

Figure 80 below has been included in this results section to illustrate the between-subject and between-interval differences in the accuracy of intervals produced in the two contexts. Note that each subject's deviation in the PME is shown in grey, with the PMS shown in colour.



**Figure 80. Between-subject differences of intervals sung in pitch matching exercises and song phrases**

Figure 80 shows that for subject C and E who were the most inaccurate over all, the production of smaller intervals – the major and minor 2<sup>nd</sup>, were more accurately produced within the song phrases, whereas the larger intervals (major 3<sup>rd</sup> and perfect 4<sup>th</sup>), were more accurately sung in the PME. Due to the high degree of accuracy in overall pitch matching for subject B and D, there were no obvious differences between their performances within the song phrases and within the PME. However, the differences between the two contexts should be interpreted with caution because there were a limited number of intervals present in the song phrases, these all being smaller intervals (not exceeding a perfect 4<sup>th</sup>). In fact

the song phrases analysed for subject B and D only contained two intervals, with subject D's limited to a maximum of a major 2<sup>nd</sup>.

#### **6.4.4 Discussion on pitch matching and its relationship to speaking intonation**

The results reported here show inconsistent findings between subjects with respect to both immediate and long term changes to pitch matching intervals regardless of context (in exercises or in song phrases) (q.2c). Some subjects improved in their accuracy within the song phrases (subject B and E), while others did not (subject C), and some subjects improved long term in their pitch matching in the exercises (subject B and D), while other subjects became worse (subject C and E). In comparing the long term changes between PMS and PME, the PME showed greater improvements or deterioration long term, than the PMS. However, overall, the accuracy in interval production was higher in the PMS (when Figure 74 and Figure 78 are compared) although this was evident only for the smaller intervals. Comparisons between the PMS and PME may not be appropriate due to the noticeable lack of larger intervals contained within the songs sung by the subjects, and the song phrases analysed.

As mentioned in the case studies (subject C and subject E), poor concentration, and impulsive and perseverative behaviour were likely to have interfered with the accurate performance of subjects in the PME. Therefore, the subjects' highest potential in pitch control may not have been realised and therefore reflected in the PME data. Their performance in the PME may represent these subjects' ability to attend and follow directions rather than represent the subjects' ability to control vocal pitch changes. This issue will be addressed in the discussion presented in Chapter 7 (7.1.4).

Of particular interest, and an issue to be further discussed in the next chapter, is the finding that the smaller intervals are more accurately produced than the larger intervals, this being typically the case with non-brain injured people as well. A thorough examination of this phenomenon through tracking the long term changes to specific intervals was beyond the scope of this thesis and future researchers should consider extending this line of investigation.

With regard to the connection between the sentence data and the changes to pitch control, it is clear from the results of subject D, that improvements in intonation expressivity, can be linked with improvements made in pitch control (q.3c). Subject C and Subject E also made improvements in their intonation potential, however, they did not

display improvements in pitch control. Like subject D, subject B improved his pitch control in the exercises provided and in the song phrases, however, these did not correspond with increases in  $F_0$ , SVS and slope. These findings suggest again, the idiosyncratic nature of subject response to treatment.

Chapters 5 and 6 presented the results for each of the four case studies and for the data pertaining to the subjects' pooled results. Data interpretations and small discussions accompanied each section of these two chapters to introduce the reader to some aspects requiring further discussion and to explain some of the trends that were detailed. The following chapter serves to elaborate further on some of the more important issues raised in the results section and to discuss these results in relation to the research questions and previous literature.

## CHAPTER 7

### DISCUSSION AND CONCLUSIONS

This study focused on determining whether a song-singing program will improve the affective speaking intonation of people with TBI. Further, the study explored what kind of changes in affective intonation occurs and what role changes to vocal singing range, mood and pitch control may have in facilitating such changes. The following chapter reviews the findings related to the proposed research questions with reference to the body of previous research. Discussion reflects on the changes in the expressive potential of people with TBI and how this relates to corresponding changes in vocal range, mood and ability to control pitch in singing songs and in exercises. To avoid repetition, some of the discussion points referred to in the results presented in Chapter 5 and 6 have not been referred to here.

Later in the chapter, a critique is provided of the research design with reflections and recommendations on a range of issues including: case study design, the therapy intervention, and the problems of conducting research within a clinical setting. A thorough discussion on the data collection, analysis procedures and assessment tools has been provided so that the clinician and researcher may be informed of the difficulties and dangers involved in setting up data collection and analysis in this way. Following this, an overview of the clinical applications and implications of these research findings are presented with recommendations for clinicians practising in this field. The final part of this chapter presents the main conclusions and a personal reflection on the process of conducting this project.

#### **7.1 Main findings and relationship to previous literature**

##### **7.1.1 Changes to affective intonation contours**

###### ***Main findings and related theory***

The main research question posed in this study was: Does song singing improve the affective intonation of people with TBI? And if so, in what ways do these changes manifest in affective intonation contours (q.1)?

The results reported in Chapters 5 and 6 showed first that song singing can improve the expressivity of intonation contours in people with TBI. It was shown that all three components of intonation analysed in this study were positively affected by the treatment although these improvements were only evident in three of the four cases. The first case, subject B, showed a conspicuous effect contrary to the other subjects, his responses strongly influencing the results of the pooled data. It was argued earlier that his response was still regarded as an improvement despite a decrease in  $F_0$ , SVS and slope because these lower measures were reflective of his pre-trauma vocal style.

It was found that in the long term, the treatment had the most impact on the  $F_0$ , as shown by the effect sizes, particularly for improving subjects' ability to express anger, where the long term effect size was large and statistically significant (Figure 70). Increases in the variability of pitch within the voice (SVS) were found in some subjects but not others. Changes to slope were variable both between and within subjects, with no distinct patterns emerging.

While improvements in the subjects' potential for expressivity were evident in three of the four subjects, the results were inconclusive as to whether subjects became better able to differentiate between the different emotions they were trying to express (q.4). Improving subjects' ability to speak at an appropriate pitch height, use variable pitch changes, and to use varying degrees of slope effectively within speaking contours is important to enable them to engage in conversation. It is also important that people with TBI are able to manipulate these different intonation components to allow them to accurately express the subtle changes in their emotional states. Prior music therapy research has not yet addressed this aspect of communication rehabilitation and although this research has not been able to draw any conclusions, trends in some subjects suggests researching this idea further is warranted. With regard to the subjects' ability to differentiate between different emotions, some subjects became better able to do so while others did not.

One important finding evolving from this research is that immediate effects of treatment were in the direction contrary to that suggested by the previous literature. It was found that at the post-session, the measures of the  $F_0$ , the SVS and the slope were often lower than those produced in the pre-session. As alluded to in Chapters 5 and 6, fatigue has been suggested as a plausible explanation for this outcome given the effort involved in participating in treatment. The issue of fatigue is explored more fully under the section discussing mood changes (7.1.3).

While the immediate effects of treatment were generally in a direction contrary to that suggested by previous research presented in chapter 3, it was found that over the course of treatment, the pre- to post-session differences became smaller or reversed, suggesting that the treatment was having a different effect in later sessions. This means that subjects were able to maintain their pre-session task performance at the post-session and in some cases demonstrate immediate improvements. Therefore, this study showed that several sessions of treatment were necessary before the immediate benefits of the treatment began to have an impact on observable outcomes. Perhaps here, the subjects require familiarity with the treatment before its maximum effects are realised. This is discussed more thoroughly on page 249.

### ***Relationship to previous music therapy research***

The data presented in chapter 6 showed that the  $F_0$  was the component of intonation that increased to the greatest degree in three of the four subjects. In the long term, effect sizes were significant for the  $F_0$  ( $d = 0.31, p = .02$ ). This is comparable with the findings of Haneishi (2001) whereby effect sizes were large for the  $F_0$ <sup>34</sup> ( $d = 1.53$ ). It is clear here, however, that Haneishi's effect sizes were much larger than the present study, suggesting that the size of the effects might depend on the pathology of subjects or the degree of severity of their neurological impairments at the time of treatment. Further, the intervention in Haneishi's study included a greater proportion of vocal exercises than was present in this program, potentially accounting for differences in the size of the effects between the two studies. This raises questions regarding the potential benefits of vocal exercises in comparison with the singing of songs, in particular, the proportion of each session designated for each of these interventions.

The effect sizes for the long term changes to SVS were comparable with Haneishi's (2001) study (Haneishi's  $d = 0.1$ ; the current study  $d = -0.15, p = .39$ ). Despite this, the results between the two studies, were in disagreement with respect to the direction of the effect, the present study finding an overall decrease in SVS<sup>35</sup> and Haneishi's finding an overall increase.

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<sup>34</sup> As mentioned in Chapter 3, these effect sizes were calculated by this researcher based on descriptive data presented in Haneishi's article and not calculated by Haneishi himself.

<sup>35</sup> Note here that subject B's strong reverse trends and over-exaggeration during the initial sessions substantially influenced this negative effect.

In this study it was found that the long term effects of treatment were larger than the immediate effects of treatment. Further, the long term effects were in the expected direction (a long term improvement) whereas the immediate effects were in the direction contrary to that anticipated based on the previous related research in this area (the post-session measures were poorer than the pre-session measures). This finding was consistent with Haneishi's (2001) findings that the long term effects were larger than the immediate effects. However, unlike the present study, Haneishi's immediate effects were also in the expected direction. Differences in cognitive function and/or degree in the severity of neurological impairment between Haneishi's subjects and those in the present study may explain these differences. Interestingly, Haneishi's subjects were not selected based on a certain stage in the progression of the disease suggesting that his subjects may have presented with varying degrees of impairments. Similarly, subject selection in the current study was not influenced by the degree or site of neurological injury. Therefore, this explanation is speculative.

Differences can also be explained in that the data analysed in Haneishi's study and the present one also differed. Haneishi asked subjects to read the *Rainbow Passage* (Fairbanks, 1960) and analysed the data for  $F_0$  and  $F_0$  variability. In contrast, subjects in the present study were asked to say a series of given sentences using intonation contours representative of the emotions they intended to express. Perhaps the task of intoning colour into the spoken reading of the *Rainbow Passage* was easier than the task of intoning emotion into sentences. The text in the *Rainbow Passage* is longer than those in the present study, providing the subjects with an opportunity to become absorbed in the text and its colourful images. This may allow the subjects a greater opportunity to demonstrate variable intonation contours than the task in the present study. Another factor also might be that the subjects in Haneishi's study were not asked to intone emotion, but intone colour to express the images portrayed in the text. Conversely, the subjects in the present study were intoning emotion, which may be more difficult to achieve than creating colourful images. This could be particularly difficult for subjects asked to intone an emotion that they were not feeling at that moment. At the same time, intoning emotion into statements about emotion may be easier to achieve than intoning colour which may be considered more abstract and therefore more difficult. Establishing the most appropriate task for which to measure subjects' best performance of intonation requires further exploration.

The current study also supports the findings of Darrow & Starmer (1986) who found statistically significant improvements in the  $F_0$  of hearing impaired children



following their participation in song singing interventions. Given this, and the similar findings also evident in Haneishi's (2001) study, the results suggest that the effects of this treatment intervention on intonation exist irrespective of the origin of the impairment. This hypothesis points to the need for future investigation into the development of treatment interventions for people with impairments in  $F_0$  irrespective of the pathology underlying the impairment.

Viewing the trend lines for each case in Chapter 5, the results suggest that cumulative effects of treatment were evident whereby the pre/post-session differences became smaller towards the end of the program and in many cases the post-session scores became greater than the pre-session scores. This led to the notion that subjects require exposure to and practice of the treatment, before its immediate benefits are realised. As a consequence of Wigram's (1993) study of clients with challenging behaviour and learning difficulties, he proposed that periods of treatment familiarisation should occur before collecting data on treatment outcomes. The proposal is that being involved in treatment procedures may be threatening for some clients and therefore their responses are not accurate reflections of their level of functioning during the initial stages of treatment. The trends reflected in this study align with Wigram's idea of the necessity for treatment familiarisation – a base line period. This finding is important for clinicians, as they need to be aware that treatment can take time before positive results are observed. It is possible that the over-exaggerated responses that some subjects displayed during the early phases of the program might be explained by this concept. In the initial sessions, they had not yet fully understood the purposes of the treatment, requiring time to become familiar with the tasks and what was expected of them. This over-exaggeration of response, and perceived need for treatment familiarisation, was also characteristic to one of Cohen's (1995) subjects. She found in her first case, that the subject's  $F_0$  range was high in session one (130Hz) but dropped considerably at session two (95Hz), never rising above 100Hz for the remainder of the program. In the present study, subject B presented with a similar pattern of response to that of Cohen's subject (Figure 19 and 20).

Noticeable findings relating principally to the  $F_0$ , and to a certain extent, the slope measures, were that responses pre- and post-session, and between sessions were highly variable. This was the case for all subjects, albeit for some more than others (Figure 66 and 68). Cohen (1995) also reported such variability in the subjects' responses to treatment. Her two subjects with neurological injury reported high variability in responses. Inconsistencies in responses could relate to subjects' variability in attention and

concentration, this being typical of people with neurological damage. Further, this illustrates that clinicians should not expect a gradual and consistent improvement in function but rather expect gradual improvements accompanied by variable responses.

One important finding highlighted by this study was that subjects' responses to treatment were highly idiosyncratic. All four subjects presented differently in the way they completed the various assessment tasks, the way they responded to treatment, and their long term improvement in intonation. Similar findings were evident for Cohen's (1992; 1995) studies where subjects responded dissimilarly to the music therapy intervention. For example, in her 1992 study, some of her subjects displayed increased  $F_0$  while others displayed decreases in  $F_0$ . The two control subjects also decreased their  $F_0$ , which raises questions regarding what role natural recovery plays in this process. Such idiosyncrasies found both in Cohen's studies and the present one, may relate to between-subject differences in lesion site and severity of TBI, time since trauma, and the potential for improvement. Additionally, between-subject differences in factors such as proneness to fatigue, poor concentration and other related cognitive impairments, as well as cultural and individual factors may also contribute to the idiosyncrasies.

### **7.1.2 Influence of voice range on affective intonation**

#### ***Main findings and related theory***

This research sought to establish whether singing songs expanded the VR of subjects whose VR has been restricted as a consequence of TBI (q.2a). Additionally, the research explored whether changes in VR correlated with improvements in  $F_0$ , SVS and slope (q.3a).

The effect size calculations reported in Chapters 6 showed that in the long term, a statistically significant increase in VR was recorded when the subjects' data were pooled. However, increases were only evident for three of the subjects. Subject B did not increase his VR but rather maintained an already wide (and adequate) VR, this VR being substantially wider than the other three subjects (Figure 72).

The pooled data showed no consistent patterns in the immediate effects (pre- to post-session) of treatment. Overall effect sizes indicate that subjects displayed a narrower

VR post-session when compared with the pre-session. Such decreases in VR post-session may be indicative of vocal or cognitive fatigue.

In order to convey varying emotions, the speaker must have the ability to utilise a wide VR. This will enable the speaker to use pitch dynamically to create subtle differences in  $F_0$ , SVS and slope in order to express a range of different mood states (q.3a). This was the first study that attempted to correlate improvements in VR with improvements in the  $F_0$ , SVS and slope in people with TBI. Positive correlations were found between the VR, slope and SVS signifying that as subjects' VR increased, they demonstrated greater pitch variability and expressive contours.

Research concerning vocal physiology can be applied here to explain this correlation. Several studies report that a wide VR corresponds with low vocal tension and high levels of vocal fold elasticity and flexibility (Abe, 1980; Aronson, 1990; Bunch, 1997; Kitch & Oates, 1994; Newham, 1999; Pittman, 1994; Stengel & Strauch, 2000). In the absence of this elasticity, the tension-relaxation of the vocal folds is compromised, thereby restricting range and limiting the possibilities for large SVS and steeper slopes (Welham & Maclagan, 2003). Therefore, the increased VR, SVS and slope of the subjects in this study could be accounted for by a lower vocal tension and the corresponding increase in vocal elasticity.

This argument is further supported by the negative correlations found between the  $F_0$  and VR. This correlation shows that the  $F_0$  decreases when the VR of the subjects is increased. As a low  $F_0$  is indicative of reduced tension, this finding further supports the argument that subjects' vocal tension decreased over time in response to treatment.

If improvements in  $F_0$ , SVS, slope and VR are linked to the degree of vocal tension and the maximised elastic potential of the vocal folds, it would seem that the treatment – active song singing – facilitated a process of reduced vocal tension in the subjects. As vocal tension signifies physiological and emotional tension, stress and anxiety (Aronson, 1990), it can be argued that singing songs had the effect of reducing overall tension, including that of vocal tension (q.2b). It was conspicuous in the VAMS scores that subjects reported a long term decrease in tension supporting this theoretical position. Further elaboration on this theory will be explored in the next section of the thesis (7.1.3).

At this point, it is also relevant to link the variables of VR,  $F_0$ , SVS and slope reported here with the differences in these variables found between singers and non-singers. Inconsistent and statistically non-significant differences in the  $F_0$  have been shown to be evident between singers and non-singers (Awan, 1993; Brown et al., 2000; Brown et

al., 1993; Morris et al., 1995). Conversely, singers were found to have a greater speaking range than non-singers (Awan, 1993; Brown et al., 2000; Brown et al., 1993; Morris et al., 1995) supposedly an outcome consequential to the extensive daily training to which their vocal mechanisms are subjected. As singers have a greater VR and speaking range than non-singers, it predisposes them for greater potentiality to be verbally expressive when compared with non-singers. Given this, it is feasible to propose that the increase in VR (and its subsequent carryover effects to the speaking voice) evident in the subjects within this study, are comparable with the same effects that singing has on the VR, SVS and slope of singers. The notion that singing trains the voice to use a wider range of pitches thereby enhancing vocal expression is supported by the results of this study.

### ***Relationship to previous music therapy research***

This study documents the improvements in VR that occurred in a group of subjects with TBI who participated in a song singing treatment program. The findings concur with those of Haneishi (2001) who studied improvements in the vocal characteristics of Parkinson's disease patients. In his study, subjects' recitations of the *Rainbow Passage* were used as data. Pre- and post-session, and pre- and post-treatment differences were analysed for 12-14 sessions of music therapy. Long term increases in VR were evident in Haneishi's study ( $M = 3.83$  semitones) however these increases did not reach levels of statistical significance. In the present study, the size of the increases in VR are not as large ( $M = 1.79$  semitones, Table 25), but these effect sizes were significant ( $p < .05$ ). Differences in the degree of variability of subjects' responses between the two studies might underpin these subtle differences in findings. It is also possible that the greater emphasis on vocal exercises in Haneishi's study might also explain the larger effect size obtained in his study given that the exercises were specifically designed for increasing vocal range. It is possible that subjects in Haneishi's study displayed greater variability in responses when compared with the subjects in the current study, leading to a higher standard deviation and hence a non-significant statistical result.

The findings reported here also add weight to the case study presented by Livingston (1996). She described the increase in VR of a woman who presented with the same pathology as the subjects in this study. Using song singing as the primary intervention, she treated the woman over a six-month period. Her client's VR increased from a monotone to 18 semitones. The subjects in the current study did not increase their

VR as substantially as Livingston's client however the subjects here were only treated for a maximum of eight weeks. Therefore, it is not surprising that the increases in VR in the current study were not as substantial as in Livingston's case given the shorter length of treatment program implemented here. Continued treatment may have led to further expansion of the subjects' VR, as there was no evidence of a plateau in improvement (with the exception of subject B). Future studies should consider evaluating the treatment over a longer period of time given that an eight-week period of intervention is rather a short period of time for people with such profound neurological impairments. As a starting point, researchers could consider doubling the length of the program and then re-evaluating subjects' responses to determine whether a consistency or plateau in responses has occurred longer-term.

### **7.1.3 Influence of mood on affective intonation**

#### ***Main findings and related theory***

As mood states are acutely linked to intonation and are also potentially disruptive to treatment, this research sought to evaluate whether song singing enhanced the immediate and long term mood states of subjects (q.2b). Building on this idea, the research sought to determine whether these altered mood states significantly impacted on the intonation characteristics of the  $F_0$ , SVS and slope (q.3b). For example, the literature presented in chapter 3 proposed an argument that an increase in self-perceived feelings of anger would transfer to the voice in the form of an increased  $F_0$ , SVS and slope.

In Chapters 5 and 6 it was noted and discussed that subjects frequently reported either a flat affect or responded with polarised responses. This was problematic because there was not a normal distribution of responses and the reliability of the data is questionable. It was not clear whether subjects were perseverating and therefore reporting a flat affect for all mood scales or whether they had difficulty identifying and measuring their mood states. Nevertheless, the effect sizes calculated showed some overall trends. In the long term, mood changes included increases in self-reported feelings of happiness and decreases in feelings of fear, sadness and confusion.

In considering the challenges experienced in rehabilitation by people with TBI, these long term changes are of value to the treatment team and the long term recovery of the subjects. Generally, mood disturbances negatively impact on client treatment as clients

become overwhelmed by the intensity of their emotions and are unable to divert their attention toward the required therapy tasks (Beblo, Baumann, Bogerts, Wallesch, & Herrmann, 1999; Code & Herrmann, 2003). Therefore, the effectiveness of therapy is threatened. Ultimately this slows recovery, or even worse, limits the degree of recovery given the importance of early intervention (Kolb & Gibb, 1999). Therefore, enhanced feelings of happiness and a reduction in fear, sadness and confusion, would lead to a greater potential for maximum rehabilitation recovery. It would be of value to the discipline of music therapy to evaluate whether participation in music therapy leads to increased participation in other therapies. Nayak et al. (2001) considered therapy participation as one measure associated with an increase in feelings of happiness. Further studies are required to further document this outcome.

The finding that subjects reported increased feelings of happiness over the course of the program may have occurred because subjects enjoyed the program. Subjects may have looked forward to the opportunity to sing their favourite songs and to express themselves. Given that they may have had limited opportunities to do this elsewhere, their enjoyment of the program is likely to have contributed to their reported increase in feelings of happiness. Such increases in positive affect may have led to the observed increases in  $F_0$ , SVS and slope. The connection between enjoyment of therapy and the characteristics of intonation is worthy of further enquiry.

Subjects reported a long term reduction in tension as a consequence of singing songs over 15-sessions. This concurs with comments by Clair (2000) and Katsch & Merle-Fishman (1985) who proclaim that the mere act of singing reduces physical tension. For example, when singing, one moves from a state of tension (as air is inhaled) to a point of lower tension (when air is exhaled). Such reduced levels of tension have benefits for improving the intonation potential of the speaking voice and the overall rehabilitation process. First, increased tension results in poor body posture (which affects respiration) and reduces the flexibility of vocal folds (Newham, 1999). Therefore, if singing songs is able to directly reduce this tension, posture and vocal flexibility are likely to improve, this being reflected in the expressiveness of the speaker. Second, as increased muscle tone (muscle tension) restricts the range and flexibility of muscles, any overall reduction in tension may allow people with TBI to more effectively participate in physiotherapy or occupational therapy and lead to better treatment outcomes for the clients.

Another finding arising from this study was that the results showed a long term increase in feelings of fatigue. Fatigue is problematic in the rehabilitation process as

patients are not able to sustain the necessary participation in the treatment to obtain the maximum rate and degree of recovery (Prigatano, 1999b). However in this study the subjects continued to demonstrate improvements in the intonation and VR measures and it did not appear to impede the treatment process. The results from this study did not collect and therefore did not identify what other events/therapies the subjects were participating in which might contribute to their long term increase in fatigue. Further studies focused on the long term effects of treatment need to analyse the influence of events and other therapies which might influence the degree of participation in music therapy and their energy levels.

In contrast to the long term effects, the immediate effects of treatment on mood showed responses in a direction contrary to that indicated by the literature - subjects reporting being more afraid, more angry, and more sad. This could be considered as having negative implications for treatment in that a decrease in therapy participation may result from increases in sadness, anger and fear. Consequently, subjects may not have participated to the same degree as they may have if their mood had lifted. This study did not collect data on therapy participation levels and therefore conclusions here are tentative. Conversely, increases in feelings of sadness, anger and fear can be viewed as positive responses to treatment in that subjects may be acknowledging feelings which are reasonable to expect for people who have experienced this type of trauma. Acknowledgment or an awareness of these emotions allows people with TBI to address and process their situation, a vital step towards acceptance. At the same time the researcher's experience of working through issues of adjustment with this population is that poor memory and poor insight prevent or slow down this process. For example, memory problems impact on the process because clients come to therapy having forgotten that they had discussed/explored these issues in previous sessions. Therefore, if a raised awareness of these emotions was a consequence of treatment, perhaps the music enabled the experience of emotion to reach the threshold for memory (Baker, 1999). The long term effects of this may be linked to the decrease in sadness, fear and confusion and increases in happiness as was reported, signifying the possibility that this process was active. Several possible explanations for why the singing of songs activated the immediate responses to treatment will be addressed on p.260.

The literature suggested that the singing of songs would enhance the long term mood state of subjects in this study. A point worthy of discussion concerns the relationship of the mood conveyed in the song material, with the actual mood responses subjects

displayed. It was noticeable in the song analyses that nine of the 12 songs employed were assessed as portraying sadness due to their text about loss (mainly loss of a love relationship) and the prevalence of minor tonality. Other musical parameters such as slow tempo, resolving dissonant harmonies and static or lack of rhythmic movement were also common to the majority of these songs. Nevertheless, subjects reported an increase in happiness and a reduction of fear, sadness, confusion and tension in the long term, this being incongruent with the mood states portrayed in the songs. Such a finding might suggest that the mere act of singing preferred songs overrides any long term negative emotional response to music.

A second explanation may be related to the idea that the emotions expressed in the songs were reflective of the emotional states experienced by the subjects during the sessions they were receiving treatment. By engaging in the singing of these songs, the subjects are in effect singing about their own feelings and the very act of doing so allows them to release and let go of pent up emotions – a cathartic effect. Turry (1999) describes similar effects of improvised songs when working with hospitalised children. She argues that the tension underlying emotional energy is released and dissipated so that uncomfortable emotions such as sadness, fear, or anger can be safely acknowledged and explored. She further adds that the act of *singing* (as opposed to listening) allows the person to express and take ownership of the stated feelings. In this sense, the songs may have provided an appropriate avenue for emotional expression, which led to an overall enhancement of positive mood states and a decrease in the negative mood states. However, the subjects in this study were never asked to confirm whether the songs they sang matched their perceived mood states. As subjects had difficulty in identifying and measuring their own mood states, it is unclear as to whether they would have the cognitive ability to make these links. Nevertheless, evaluating whether the act of singing songs provide a cathartic effect is worthy of further examination.

Building on the idea of an emotional release is the possibility that repeated singing of the same song may have enhanced the songs' power to release these emotions. Sloboda's (1991) research findings are relevant here because he found that an emotional response to a piece of music increases through repeated exposure. Consequently, repeated singing of the song might be said to have increased subjects' responsiveness to it, increasing the songs' cathartic potential<sup>36</sup> and in turn, enhancing mood long term.

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<sup>36</sup> Cathartic effects are those where a person's energy is ejected through the act of music making, this giving relief to the person (Pavlicevic, 1997).



Repetition of singing songs might also explain why the homeless men in Bailey and Davidson's (2003) study experienced catharsis of past hurts and trauma when rehearsing songs in a choir, the act of repeating them intensifying the songs' emotional power. For the present study, these songs were subject-selected and therefore the subjects presented themselves with a predisposed sensitivity to these songs. They may be more likely to respond emotionally to their own songs than new or unfamiliar song material, not only because of their relationship to self-chosen songs, but because they have listened to (or even sung) these songs on several occasions prior to being admitted to the study.

Another explanation arising from the long term enhancement of mood might relate to the development of a relationship between the subject and the therapist, even though that was not the intention of this study. The fact that the therapist provided one-to-one music therapy treatment two to three times weekly may have resulted in the subjects feeling like they were being listened to and attention was paid to them. Consequently feelings of self-worth may have become enhanced, thus resulting in improved mood.

While the musical material appeared to have a long term cathartic effect on subjects, the reverse situation emerged for the immediate effects of treatment. Post-session, subjects became more afraid, more angry and more sad. Again, an analysis of the song material provides possible explanations for these findings. As mentioned, nine of the 12 songs were characteristically expressing sadness, frustration, and anticipation (of fear). If the subjects were also experiencing these feelings at the beginning of the session, participating in the singing of songs which matched their feelings may have intensified their experience of them. Katsch & Merle-Fishman (1985) and Austin (1998) state that singing songs gives voice to intense pain, fear and anger, and in doing so one begins to experience and express more intense emotion. Such intensification may have brought these feelings to a level of conscious awareness leading to the subsequent reported increases in these feeling states post-session.

Therefore it can be proposed that choosing songs in therapy is valuable in that the choices often mirror the emotions of the clients as they experience them in the moment (Hogan, 1999; Montello, 1998) and while this has the effect of intensifying emotions, the long term benefits are one of reduced sadness, anger, fear and tension and increased feelings of happiness. The power of songs has been aptly described by Bruscia:

*Songs are ways that human beings explore emotions. They express who we are and how we feel, they bring us closer to others, they keep us company when we are alone. They articulate our beliefs and values. As*

*the years pass, songs bear witness to our lives. They allow us to relieve the past, examine the present, and to voice our dreams of the future. Songs weave tales of our joys and sorrows, they reveal our innermost secrets, and they express our hopes and disappointments, our fears and triumphs. They are our musical diaries, our life-stories. They are the sounds of our personal development.* (Bruscia, 1998, p. 9).

In contrast, Magee (1999b) cautions that clients sometimes choose songs as coping mechanisms, not always choosing songs that mirror the clients' emotional state, but selecting songs that are happy, fun, cheerful or positive as a way of coping with their situation.

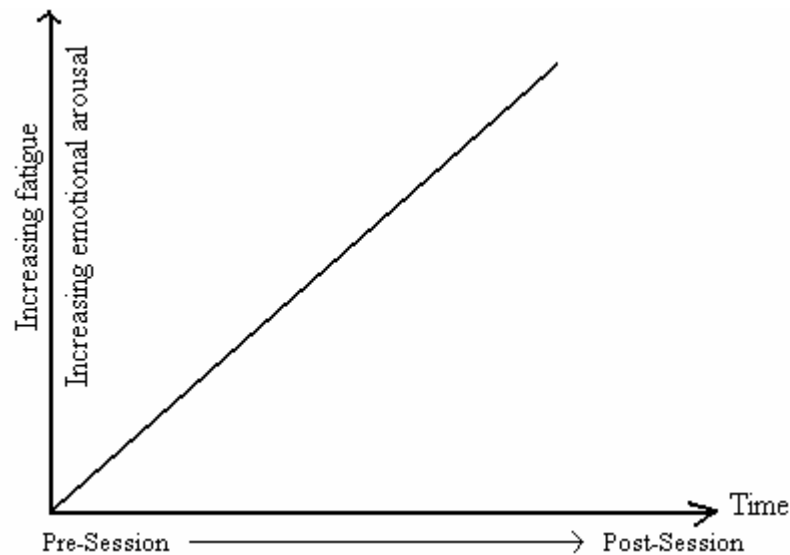
The extent to which the lyrical content compares with the musical parameters in their evocation of mood states may explain why singing songs had such a strong negative effect on mood at the post-session in this study. Gfeller, Asmus, & Eckert (1991) studied the effects of music, text, and the combination of music and text, on the mood states of college students. Not surprisingly, they found that when music and text were combined and in agreement as to the targeted emotional response, subjects reported experiencing the emotion to a greater degree than when the music or the text were experienced separately. However, when the responses to music and the text were compared separately, subjects reported that the text tended to evoke stronger emotions than the music. Stratton & Zalonowski (1994) also found that lyrical content was more powerful in evoking mood responses than the musical content in altering mood states in listeners. This is possibly because lyrics of songs evoke response from subconscious as well as conscious processes (Kaser, 1993). In the current study, most of the songs' lyrical themes were about sadness, loss, frustration, and anticipated fear. However, the musical parameters did not always reflect these mood states. This was particularly apparent for the songs employed in subject E's sessions where the thematic material of the lyrics portraying emotions of sadness and despair, were incongruent with the musical parameters which were more expressive of happy and excitement as evident in major harmonies and fast tempos. If Gfeller et al.'s (1991) and Stratton & Zalonowski's (1994) findings hold true for people with TBI, then this would suggest that the lyrical content (representing sadness, frustration etc) had a stronger effect on mood states than the positive mood states conveyed in the music parameters for subject E.

A thorough structural analysis of the music and lyrics was beyond the requirements of this thesis in answering the research questions. Therefore, a closer examination of the

relationship between the lyrics, musical parameters and mood responses of the subjects was not attempted. Even so, understanding the complexities of songs' effects on mood states would be important for music therapists attempting to select songs in treatment. Familiarity and musical components might not be sufficient grounds for assuming songs will affect mood in the direction intended, their effects likely to be more complex than this. For example, Gfeller et al. (1991) and Stratton & Zalonowski (1994) only examined the subjects' responses to music listening and not how lyrics and musical structure influence mood states when people actively engage in singing.

Rider, Mickey, Weldin, & Hawkinson (1991) studied the effects of listening and singing on the psychological and physiological responses of college students. Results of the Profile of Mood States showed that the group engaged in song singing reported less depression than the music listening group. Whether music listening and singing have equal effect on the mood states of clinical subjects is yet to be delineated. It is unclear as to why active participation in singing impacts on changes to mood states but perhaps singing acts as a positive coping mechanism for dealing with the issues relevant for the clients. Conversely, listening may facilitate more reflection and subsequently increased levels of sadness. Perhaps the change in mood states of people listening to their favourite songs could be compared with their changes in mood states following their active singing of their favourite songs. Addressing these concepts through further investigation is recommended to determine the validity of the researcher's proposals.

One observation of the immediate effects of treatment was that as the mood states of anger, sad and fear tended to increase from pre- to post-session, experienced feelings of tiredness also tended to increase. This might suggest that while singing intensified the feelings of the subjects, experiencing these emotions was fatiguing. People feel more tired after intense emotional experiences and this is supported by the literature that links fatigue with depression (for example Voss, Arnett, Higginson, Randolph, Campos, & Dyck, 2002). Figure 81 provides a diagrammatic representation of this relationship.



**Figure 81: Relationship between feelings of fatigue and increased emotional arousal**

When correlations between the mood scales and the three intonation components were calculated, many negative correlations were found. Precisely, the correlations showed that as subjects' moods became more intense (more happy, more sad, more angry etc), they presented with a lower  $F_0$ , lower semitone variability and a slope with a flatter gradient. This was especially highlighted for correlations with SVS where many of the negative correlations were highly statistically significant (see Table 25). These findings were in the direction opposite to that suggested by the previous literature.

The concept of optimal arousal provides a possible base for explaining these negative correlations. When the subjects reported experiencing a heightened state of emotional arousal (happiness, sadness, anger etc) as indicated by high scores on the VAMS, they may have been quite preoccupied with the thoughts and feelings associated with these emotional states. Heightened states of emotion are often referred to as hyper-aroused states with this population, which lead to a decreased performance in tasks requiring attention and concentration (Yerkes-Dodson Law, 1908 cited Glass & Holyoak, 1986, p.102). Given that the sentence tasks required subjects to apply a certain degree of *effort* and thought into the completion of these tasks, the heightened intensity of their emotions may have prevented them from doing so to the same performance level as when

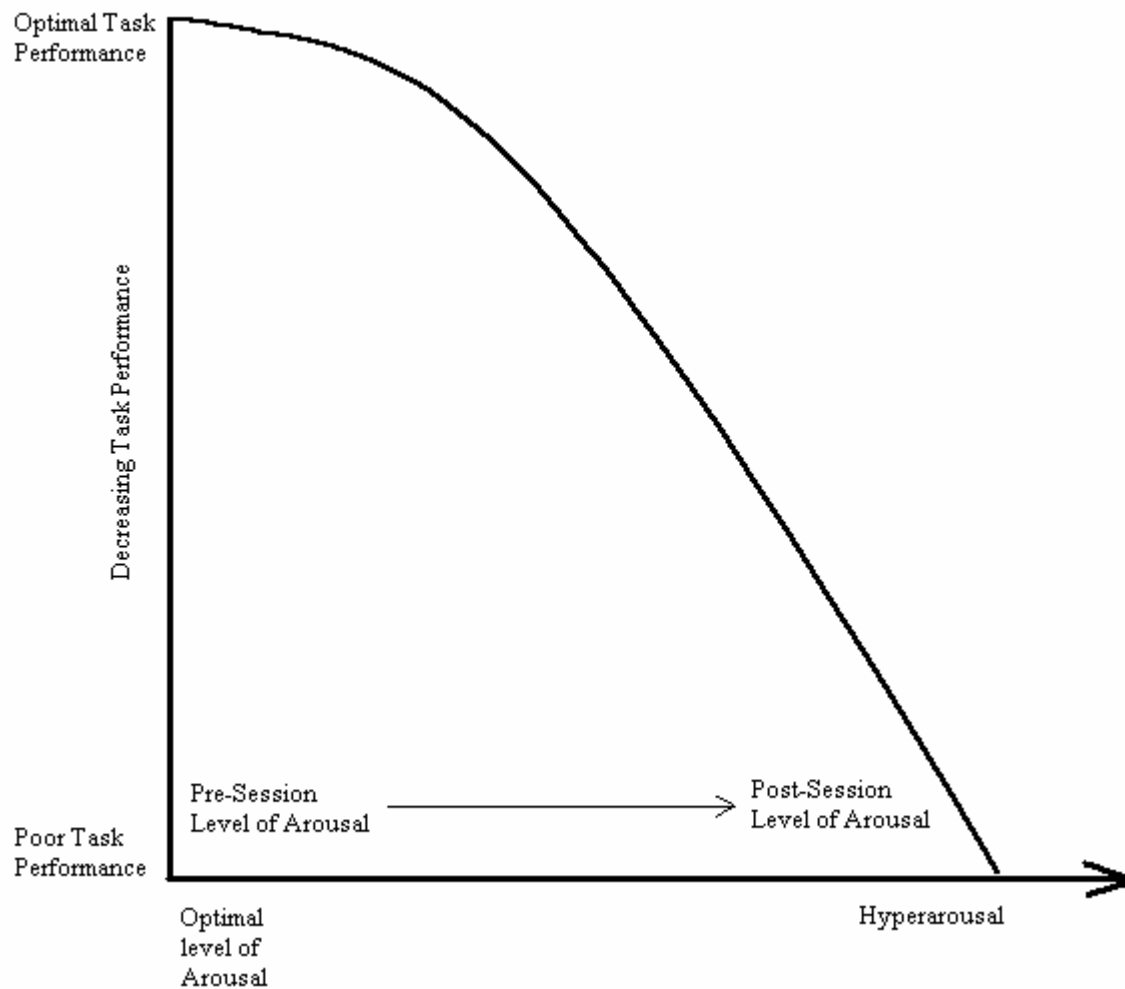
their affect was not as intense.<sup>37</sup> Adding to this argument is the finding that subjects reported feeling more sad, more afraid and more angry post-session and also demonstrated a poorer performance on all post-session assessment tasks (sentence tasks, VR and PME) when compared with the pre-session assessments. Nevertheless, one can hypothesise the following set of events occurring as a consequence of the singing of preferred songs:

|                  |  |
|------------------|--|
| Pre-session      | <ul style="list-style-type: none"> <li>- overall flat affect reported</li> <li>- optimal arousal for task performance</li> </ul>   |
| Singing of songs | <ul style="list-style-type: none"> <li>- participation results in feelings of fatigue</li> <li>- music facilitates an increase in sadness, anger, and fear</li> <li>- emotional arousal increases</li> </ul>   |
| Post-Session     | <ul style="list-style-type: none"> <li>- overall increases in sadness, anger, and fear are reported</li> <li>- subjects in a state of emotional hyper-arousal</li> <li>- subjects experiencing feelings of fatigue (from physical participation and heightened emotional intensity)</li> <li>- poorer performance on tasks at post-session assessment when compared with pre-session assessment</li> </ul> |

Figure 82 illustrates the relationship described in these series of events diagrammatically.

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<sup>37</sup> This author discussed the usefulness of this model in an earlier study with people experiencing posttraumatic amnesia (Baker, 1999; Baker, 2001a).



**Figure 82. Pre- to post-session processes using Yerkes-Dodson's (1908) theory of arousal**

These ideas are speculative but presented here in order to hypothesise how the phenomena that occurred may be causally linked. This is also worthy of further investigation.

### ***Relationship to previous music therapy research***

Findings from this study add to the growing body of literature supporting the effect of music therapy on the immediate and long term mood states of people with TBI (Magee & Davidson, 2002; Nayak et al., 2001). One finding - that immediate effects were in the direction contrary to that expected - contradict those reported by Haneishi (2001) in his work with Parkinson's Disease patients. His study reported an increase in positive mood states at the post-session. Nevertheless, one must bear in mind, that only one bi-polar scale

was used to assess mood in his study. In contrast, the present study employed eight uni-polar scales. Similarly, the results reported here do not support the findings described by Magee & Davidson (2002). In their use of a condensed version of the POMS-BI, immediate and statistically significant decreases in anxiety, hostility and fatigue were noted. In comparison, increases in fear, anger, sadness and fatigue were reported here. These differences may be attributed to choices in therapy interventions, the music material employed or differences in subject-pathology, or skill of the therapist. These differences also lend further support to the notion that people with neurological damage respond in idiosyncratic ways.

Contradictory findings between the present study and those of Haneishi (2001) and Magee & Davidson (2002) signify the need for further investigation into the immediate effects of treatment on mood states in people with neurological damage. Answering questions regarding which mood states are immediately influenced by treatment, the choice of intervention which best facilitates these outcomes, and the most effective musical material to do so, will result in more effective treatment.

Unlike the immediate responses, the long term effects of song singing on mood were in the expected direction as subjects became happier and less afraid, sad, confused and tense. These findings do strengthen the reports of Nayak et al. (2000) and Haneishi (2001) whose subjects became less sad. However, their studies chose to focus solely on the happy-sad (bi-polar) scale and not the six additional uni-polar mood scales presented in the current study. This was the first study to explore the long term effects of a music therapy treatment program on the mood states of confusion, anger, fear, tension, energy, and fatigue for people with TBI. Further investigation into the complex relationship between music therapy treatment and mood states with people who have TBI, is called for. Magee & Davidson (2002) propose that music therapy treatment affects some mood states to a greater degree than others.

In Waldon's (2001) music therapy study with oncology patients, long term decreases in feelings of sadness, confusion and tension reached levels of statistical significance. Although the results of the current study were inconclusive, the trends analysed support Waldon's findings. Even so, Waldon (2001) also found that his subjects reported a decrease in feelings of fatigue, which was opposite to the effect reported here. It is possible that these conflicting findings relate to differences in pathology.

To the author's knowledge, this was the first study that has explored the interaction between mood states and intonation characteristics in people with TBI whilst participating

in a song-singing program. Negative correlations were found between mood states and  $F_0$ , SVS and slope signifying that as subjects experienced moods more intensely, their  $F_0$ , SVS and slope decreased i.e. they became more monotonal. Although Haneishi's (2001) study did not calculate correlations between intonation measures and mood states, a comparison between his findings and the current study are valuable here. The fact that mood states,  $F_0$ , SVS (expressed as fundamental frequency variability), and VR all increased in Haneishi's study, suggest that mood states and intonation are causally linked in a positive direction – that is, as mood become more intense, the  $F_0$ , SVS, and VR also increased. Haneishi's finding is therefore incongruous with the present findings. It is unclear why these differences occurred. One possibility might relate to the different measurements used to evaluate the sentence measures and the mood states. This issue is addressed in detail later (7.2.2).

#### **7.1.4 Influence of pitch control on affective intonation**

##### ***Main findings and related theory***

The final part of this research sought to determine whether song singing had a direct effect on changes to vocal control (q.2c). It was conceptualised that by engaging in the singing of songs, subjects would improve their ability to sing intervals, this reflecting an overall improvement in vocal control. Leading on from this, it was suggested through a review of the literature, that an improvement in pitch control would carry over to improvement in the use of intonation during speaking – namely  $F_0$ , SVS and slope (q.3c).

Results presented in Chapters 5 and 6 reported inconsistent findings concerning immediate and long term changes in pitch matching accuracy (q.2c). Inconsistencies between subjects in both the PME and in the PMS were evident with two subjects improving their long term accuracy (subject B and D), while the other two subjects became less accurate with time (subject C and E).

Chapters 5 and 6 also reported that some cognitive impairments in subject C and E affected their performance, this characterised by high variability in their responses. This variability was a reflection of varying levels of impulsive behaviour, perseveration, concentration, attention, motivation and fatigue, these being common cognitive impairments in people with TBI (Prigatano, 1999b). The effects these had on the pooled results were discussed in Chapter 6 (6.4.4.) and do not require further elaboration here.



With regard to the accuracy of specific intervals contained within the PME, the smaller and easier intervals of the minor and major 2<sup>nds</sup> and 3<sup>rds</sup> and the perfect 4<sup>ths</sup> and 5<sup>ths</sup> were performed more accurately than the larger intervals (Figure 74). This aligns with the intervals that are the easiest to sing in the normal population (Davidson, 1994; Dowling, 1992). Further, these intervals utilise a smaller pitch range – this suiting the limited VR of the subjects, particularly subjects C and E.

The lecture series given by Paul Nordoff (Robbins & Robbins, 1998) about intervals may also be relevant here in understanding the subjects' more accurate performance of some intervals when compared with others. Nordoff, influenced by the writings of Rudolf Steiner (1977) and anthroposophy, described intervals as being experienced inwardly and outwardly. For example, the major 3<sup>rd</sup> was considered the interval of inner balance and the perfect 5<sup>th</sup> of standing balance. Additionally, intervals less than a perfect 5<sup>th</sup> were experienced inwardly and those greater than a perfect 5<sup>th</sup> experienced outwardly. The major 7<sup>th</sup> is the interval of which the feeling of tension between the inside and outside of a person is at its greatest. Such views of intervallic experience lead to the idea that singing certain intervals might reflect the inner state of the singer, supposed introverted or extraverted expressions. In this study, the perfect 5<sup>th</sup> and major 3<sup>rd</sup> were the most accurately sung intervals, followed by the smaller intervals of the major and minor 2<sup>nd</sup> and minor 3<sup>rd</sup>. This might suggest inner balance with a reluctance to move outside the self. However, it was also noticeable that the effect sizes showed that over time, the larger intervals became more accurate. According to Nordoff, such a finding might suggest that the subjects were becoming more confident to sing larger intervals, that is, moving outside of themselves more. Levels of confidence or measures of introversion and extraversion were not assessed, and therefore, these ideas are suggestive only and require further investigation.

The increase in accuracy of larger intervals can also be explained by the corresponding increase in VR. A narrow VR would limit the possibilities for the accurate singing of intervals. Therefore, in extending the vocal range of subjects, it was not surprising that improvements in the accuracy of larger intervals were observed.

Another important finding from this study was that overall, subjects were more able to sing accurately in the PMS than in the PME, although this difference was only true for some intervals and not others. Several findings in neuromusical research may underpin this difference. First, one must consider that the PME is a cognitive task requiring the listening, processing and subsequent initiation of a response to each interval presented. As subjects

reported that they had no prior musical training (with the exception of subject B who had instrumental training<sup>38</sup>), it is likely that this activity was novel. Consequently, subjects required optimal levels of arousal and high levels of concentration to give their best performance in the PME. In contrast, the ability to sing songs often remains intact following neurological damage, tapping into automatic response mechanisms and bypassing the cognitive processes required for the PME (Baker, 2000; O’Callaghan, 1999; Sparks, Helm, & Albert, 1974). Therefore, as poor concentration and attention are typical of TBI (Prigatano, 1999a), fluctuating performance is more likely to occur in the PME than in the PMS. This notion is further supported here because three of the four subjects displayed higher variability in the responses for the PME when compared with the PMS (Figure 73 and Figure 77).

The value of singing as an automatic response mechanism becomes more critical when subjects, such as subject C and E, present with impairments in impulse control and perseveration. Impulse control greatly hampered these two subjects’ performance in the PME because they were not able to leave an appropriate amount of time to reflect on what they had heard and then prepare their response. Instead, they were impulsive and responded without prior thought. Given this situation, the PMS was performed more accurately as it made use of already internalised melody lines – automatic recall. During the PME, subjects C and E tended to perseverate on singing the same interval or commencing on the same note. Conversely, singing in the PMS provided a continuous flow of melody, not allowing the subjects any opportunity to fixate on any single interval or note. In addition, the PMS also contained the added cue of lyrics, which may have assisted the subject not to perseverate on any particular interval or note. Recommendations for clinical practice based on these findings are discussed in 7.3.1.

Hemispheric specialisation for local (intervals) and global (contours) information might also play a role in why PMS was performed more accurately than the PME (Peretz, 1990; Liégeois-Chauvel et al., 1998). As intervals contain local information, they engage the LH. Conversely, local and global information is involved in the processing of song melodies and therefore both hemispheres are engaged. Similarly, it has been stated that

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<sup>38</sup> Incidentally, subject B performed substantially more accurately than the other three subjects suggesting that his prior musical ability was not disrupted by the TBI and remained intact. This is in support of the findings by Peretz et al. (1998) who showed that extensive brain damage responses to music appear to recruit brain circuitries that are particularly resistant to damage due to its emotional involvement.

melody involves rhythm (a LH function) and contour (a RH function). Therefore the singing melodies of songs engages both hemispheres (Borchegrevink, 1982; Cohen & Ford, 1995; Kinsella, Prior, & Murray, 1988; Peretz & Herbert, 1995; Prior, Kinsella, & Giese, 1990; Shapiro Grossman, & Gardner, 1981; and Zatorre, Evans, & Meyer, 1994). Given this, it is reasonable to argue that because the singing of melodies (PMS) engages both hemispheres, there is a greater likelihood for accurate interval production when compared with the PME in which activation of only the LH is required. If more specific information on the lesion sites of the four subjects was available, this point could have been further investigated.

Given the large between-subject and within-subject variability in responses, calculating correlations between the changes in PME and PMS with measures of  $F_0$ , SVS and slope would not have produced meaningful results and therefore was not undertaken. On reflection, the PME task required a certain pre-requisite level of cognitive ability, and in two of the subjects, this prerequisite was absent. The required prerequisites include adequate levels of concentration and attention, adequate impulse control and an absence of perseveration (recommendations for clinicians regarding this issue are discussed in 7.3.1). However, the vocal contours of the song phrases were useful in qualitatively identifying improvements in vocal control, these coinciding with the improvements in  $F_0$ , SVS and slope. Closer examination of the links between the improved vocal control evident in these song phrase contours and the ways contours of intonation change is worthy of future investigation and will be discussed in the section presenting an overview of the limitations of this study.

### ***Relationship to previous music therapy research***

While music therapy literature in Chapter 3 reported that several studies focused on improving the vocal control of people with impairments in intonation (Cohen, 1992; 1995; Cohen & Masse, 1993; Darrow & Cohen, 1991; Darrow & Starmer, 1986; Kennelly et al., 2001; Livingston, 1996; Lucia, 1987; and Zoller, 1991), none of these studies assessed pitch control in the same way reported here. However Darrow & Cohen (1991) reported that two students with hearing impairments made improvements in vocal control. As the test descriptors were not described in this report, direct comparisons cannot be made here.

No prior study has attempted to link improvements in vocal control with  $F_0$ , SVS and slope and therefore, this study provides the foundations for further research into this possible relationship.

## **7.2 Limitations of the study and implications for future research**

Undertaking case study research with complex assessments and analyses inevitably presents difficulties that influence the reliability and validity of the results. Several weaknesses in the design were identified and acknowledged prior to the commencement of this study. Such weaknesses were unavoidable due to the time constraints of the study and the lack of established assessment tasks available for evaluating some of the variables examined. However, in conducting this study, several unpredicted weaknesses emerged which undoubtedly influenced the results. Previously declared limitations and those that emerged are discussed and recommendations offered for those researchers interested in pursuing this research focus. The first part of this section discusses the limitations related to the research design while the second part moves to discussions related to the data collection and analysis process.

### **7.2.1 Method and design**

#### ***Case study design***

Researchers' main critique of case study design is that it often limits generalisability. Before new treatment interventions can be employed in the medical field, repeated randomised controlled trials are required to demonstrate the consistent efficacy of the intervention. This study presented the treatment to four subjects and each of these subjects responded differently to the treatment. In this respect, this study falls short of providing any kind of solid evidence for a consistent response. While the researcher acknowledges and values these idiosyncratic differences between subjects, no generalisations can be made at this point, although these findings can be considered to suggest trends. At the same time, the case study model was very efficacious because it

allowed a detailed analysis of varied responses of the individual subjects to show a range of responses on a small number of subjects while providing valuable foundations for a study with a larger sample. The case study model allowed a depth of detail that differentiated responses between subjects. Further investigation with a larger sample can be undertaken in order to explore more consistent responses in relevant areas to arrive at more clear conclusions of the effectiveness that would impact on the whole population.

The appropriateness of case study research for people with TBI is supported by the number of texts in the medical field who report on case studies (for example Burke et al., 2000 and Wilson, Cranny & Andrews, 1992). However more convincing to this argument is the existence of a prestigious journal *Neurocase* which focuses solely on presenting case studies of subjects with varying neurological impairments including TBI.

To control for natural recovery, the immediate effects of treatment were also evaluated. Based on the previous literature, it was expected that a positive change in the intonation measures, VR, mood and PME would result when post-session scores were compared with pre-session scores. This was not the case. Therefore, as the subjects in this study were in the active phase of recovery (within 12 months of PTA resolving), the extent to which natural recovery was a factor influencing the observed long term improvements was unclear. In retrospect, the inclusion of at least two control subjects would have enabled the researcher to assess how the improvements observed in the subjects compared with what could be expected in the process of natural recovery. For example, would the increases (or decreases) in intonation measures occur at the same rate in the control subjects as that observed in the experimental subjects. No two people's brain injuries are exactly the same and the rate and degree of natural recovery will be different for each subject. Further, recovery is usually not linear with extensive recovery occurring during the initial phase followed by stepwise improvement. Even so, there are variations on this process with some subjects remaining unresponsive to treatment for long periods with a sudden spurt of spontaneous recovery. Given this, large numbers of control and experimental subjects would be required to be certain that the two groups of subjects were well-matched.

### ***Homogeneity of sample***

This study attempted to select subjects who displayed a similar clinical presentation with regard to speaking intonation impairments, but did not attempt to match subjects

according to site and severity of lesion. The implications of this were that the research could not correlate certain lesion sites with particular responses to treatment. This study was exploratory in nature and instead offered treatment to clients with similar clinical presentation but different lesions. This provided an opportunity to observe a range of responses to treatment. Nevertheless, future research should consider attempting to match subjects for lesion site and severity so that a greater understanding of the effects of this treatment can be reached.

While the selection criteria was sufficient for recruiting subjects displaying the phenomena addressed in this study, there were no criteria to exclude subjects who displayed significant impairments in cognition – namely poor concentration, poor self-awareness and insight, and poor impulse control. In evaluating the subjects' responses, these problems impacted negatively on their ability to participate in the assessment tasks measuring the effectiveness of treatment. Researchers intending to pursue this line of inquiry need to be aware of the impact these problems have on the research project and consider including a minimum prerequisite level of cognition as part of the selection criteria. Practically speaking, it would be beneficial for researchers to assess subjects suitability during one trial session in order establish whether these cognitive issues are factors likely to influence the data collection.

At the same time, recruiting homogenous groups of subjects with TBI within a limited time frame is a challenge facing all researchers, particularly when studying phenomena that are as specific as those studied here. Such weaknesses in music therapy studies with TBI subjects will continue unless researchers can collaborate at an international level to ensure large numbers of subjects can be included in a single but larger scale study. Rosenfeld & Dun (2000) also proposed this idea at the MusicMedicine conference in Melbourne in 1998.

Recent literature (Wymer et al., 2002) unavailable at the time that this study was designed, reported on the development of classifications for disorders in intonation and proposed various lesion sites associated with these disorders. Just as was previously developed for the aphasia syndromes, a similar model is now being developed for the aprosodia syndromes. The aphasias are typically classified into motor (Broca's), sensory (Wernicke's), global, conduction, transcortical motor, transcortical sensory, mixed transcortical, and anomic. Wymer et al. (2002) propose that the corresponding aprosodias may be classified into the same categories as the aphasias – motor aprosodia, sensory aprosodia, global aprosodia etc, each associated with a particular lesion site and each with

its own characteristic presentation. While research into the aprosodias is still in its infancy, future music therapy researchers may benefit from such developments in being able to obtain matched subjects. Studies could potentially compare the differences in the effects of music therapy treatment according to diagnoses.

### ***Voice as a research tool and measure of change***

The premise of this study was that a person's voice is intimately connected with his emotional state, a mirror for the emotions, and therefore an indicator of emotional change. Given this viewpoint, it was expected that increases in affect as measured by the VAMS, would correlate with increases in  $F_0$ , SVS and slope. Intriguingly, the results from the correlations calculated in this study were to the contrary. Correlations were highly significant but in the direction contrary to that suggested by previous research. The most likely explanation addresses the notion that subjects were emotionally hyperaroused post-session and therefore not able to focus on the tasks designed to measure their voice. Therefore, when treating people who have neurological impairments in intonation, one must be cautious about over or misinterpreting client changes in vocal output as something more general about changes in their emotional state. More validation of voice measures and their connection with emotional state is required in music therapy given that clinicians frequently refer to how people use their voice. If the voice characteristics of subjects are incongruent with self-reported mood states, it could be argued that the voice is a useful tool in measuring affect. However, due to the extremes in reporting of the VAMS, further trials of this design may illuminate more reliable relationships and build further evidence for the voice as being a measure of affect. What is needed is a more precise voice profile tool which could be used to assess the voice. This research did not intend to develop a voice assessment tool but this research highlights that this is what is now needed in the profession.

### ***Song singing as an intervention***

In this study, the song-singing intervention required subjects to sing three songs selected from a list of subject-preferred songs. Although intended to control for potential differences in the ways subjects responded to different song selections, restricting the subjects' programs to three songs was limiting in retrospect. First, subjects may have become bored by singing the same three songs for the entire 15-session program. Boredom

can lead to a reduced motivation and therefore reduced performance in task completion (Prigatano, 1999a).

Second, the repetition of the same three songs may have limited the redevelopment of vocal flexibility. Introducing new musical material each session provides a continuous stream of varied melodic lines – differing in tempo, interval ordering, mood, etc. Variation is more likely to encourage vocal fold flexibility. Therefore, it is probable that in not varying the song repertoire, the maximum therapeutic outcomes were limited.

Third, the mood states represented in the three songs may not have been appropriate for the subject during every session. Given that this study attempted to link changes in mood with changes in intonation, selecting songs which reflect the mood state of the subjects is desirable. It is a limitation of this study that subjects may have been singing songs they were unable to emotionally relate to at that moment. A more appropriate design would be to allow subjects to select the songs during each session rather than pre-determining the musical content of the program at the commencement of the treatment. Future studies could attempt to link the subjects' moods closely with the musical material, an approach already described by Magee (1999a). Perhaps subjects could nominate songs they know have a unique emotional significance, particularly for the moods of happy, sad, angry and afraid, and these selections form the musical content of the therapy work. Subjects could then select the musical material that best reflects their emotional state on any particular day thereby providing opportunities for them to reflect. An extension of this idea would be to record subjects' song choices and evaluate how these change over the course of treatment. Here, changes in song choice may mirror the changing emotional state of the subjects (Bruscia, 1998).

Giving subjects choice also offers them opportunities for experiencing a sense of control and to feel empowered. Given that rehabilitation programs may be void of opportunities for choice and control, such opportunities may result in enhanced mood states that have important benefits for maximising rehabilitation outcomes. It would be valuable to understand the extent that offering choice has on enhancing mood states of clients receiving music therapy.

### ***Experimentally controlled research versus clinical research***

This study was organised to contain a research group of subjects recruited for a fixed period of therapy for the collection of data in a research study. This is in contrast to



other case study methods where the researcher studies a clinical group of patients who are participating in regular music therapy sessions. In the latter situation, the interventions and the music selections employed by the clinician may be continuously abandoned, adjusted or extended to meet the changing needs of the client and in order to facilitate the best therapeutic outcome. Further, in the clinical setting the duration and frequency of sessions and the length of the program can be adjusted according to client-performance, mood state and level of fatigue. For instance, when a client experiences fatigue, the therapy session can be terminated at the discretion of the clinician.

Within this research study, the subjects were asked to participate in a study that was not representative of a typical music therapy session. The programs were not tailored for each individual subject but designed to address an impairment that was similar across all subjects. Individual subject differences in responsiveness to treatment were not taken into account and the content of the sessions was fixed for the entire program. The only aspect of this study that provided recognition of each subject's needs was the inclusion of subject-preferred song selections. Given this, it is possible that each subject would have demonstrated greater improvements had the music therapy clinician been permitted to adapt her intervention according to individualised and varying subject responses. What needs to be taken into consideration for future research is how the clinician can have more flexibility in modifying the treatment program while maintaining a fixed research design.

Because subjects in the study were presented within a *testing* situation, the Hawthorne effect (Roethlisberger & Dickson, 1970) may have played a role in limiting the maximum therapeutic outcomes possible from this treatment. Subjects in this study presented themselves as *research subjects* rather than as clients receiving therapy. In doing so, they may have experienced an expectation to perform in a certain manner in the pre- and post-session assessments and during the intervention. Such expectations may explain occurrences of over-exaggeration of some of the sentence contours and the polarities in some of the responses on the VAMS. Further, the subjects may have been applying great effort in order to please or gratify the music therapy clinician, and in doing so, became tired. Subjects reported increased levels of fatigue post-session in their scoring on the VAMS. At the same time, the Hawthorne effect could also explain the positive results observed in the pre- and post-sessions (with the exception of the VAMS). Here, the higher pre-session scores at the commencement of the session may have been attributed to an enthusiasm to perform to a level they perceived to be acceptable to the clinician. However,

as the session progressed, this enthusiasm may have abated and might explain the commonly reported poorer performance post-session.

Conversely, because subjects were aware that they were participating in a research study, they may have intentionally tried to interfere with the study by participating in a way that might not be representative of their true selves. For example, reporting a flat affect on several occasions may be viewed as a deliberate attempt to sabotage the results.

The necessity to wear a microphone headset for the duration of each session may have been a factor influencing subjects' responses. Having their singing recorded and then used for analysis may have been confronting, intimidating and disturbing to the subjects. This factor might explain the poor performance of some subjects displayed during the PME. Subjects may have viewed the PME as a test of their musical ability, and knowing that their performance was being recorded may not have been a pleasant experience for them. It has already been shown that emotional tension negatively impacts on vocal performance, therefore the recording and wearing of the microphone headset may have contributed to vocal tension. Again, this may explain the poorer performance in the voice work, a building up of increased tension that may have occurred through the session and therefore decreased the flexibility of the vocal folds. Additionally, the long term improvement subjects displayed may be explained by the possibility that they became more comfortable with the equipment being used in the program thereby further explaining their long term positive response and the smaller pre-post session differences that occurred in the latter sessions. This adds support to the arguments for treatment familiarisation noted earlier, with subjects requiring familiarisation with the equipment. As subjects were not asked to comment on their experiences of the treatment, it is unclear as to the degree of influence this may have had. Further research should consider including this as a variable to be studied.

### ***Researcher versus clinician***

In order to prevent bias in this study, the researcher and the clinician were two different people. As a consequence, several problems arose in preparing and implementing the clinical trials. The equipment used to collect the audio data was complex and therefore subject to human error. While the research assistant was provided with training by the researcher and a detailed manual about how to operate the equipment, some data were either contaminated or lost. The implementation of more precise procedures, and a more

consistent checking of the equipment to ensure it was operational, may have eliminated some of the occasions when the data were lost or contaminated. Researchers need to be aware that clinicians may not have experience in using such advanced technology and therefore precise procedures need to be in place to avoid lost or unusable data.

### 7.2.2 Data collection and analysis

#### *Assessment tasks*

Imperfections in several of the assessment tasks designed for this study emerged during the data collection despite piloting these on clinical and non-clinical subjects prior to implementing the research.

Employing the *intonation production* tasks pre- and post-session presented a number of problems. First, the amount of audio data contained in a single sentence was considered insufficient to gauge the level of ability subjects had in expressing emotion in their voice. It might take subjects at least a few sentences to *internalise* an emotion before being able to sensitively intone that emotion in one's voice. Therefore, it would be advisable to increase the length of this task so that subjects communicate several sentences expressing each specific emotion.

Another weakness associated with this task was that subjects were attempting to artificially inflect an emotion into a sentence. The complexity of this task for subjects was underestimated by the researcher, particularly as they were asked to intone emotions that they may not have been experiencing. In future, it is recommended that subjects' audio recordings be analysed according to their perceived mood on any particular day. For example, if a subject reports experiencing anger, the intonation of his speaking is assessed and compared with the characteristics described for anger. Several sentences should be analysed to provide a broader and more accurate picture of subjects' ability to inflect emotion into the voice.

Another limitation of this task is that the subjects' responses cannot be directly compared with those arising from other studies. For example, Haneishi (2001) asked his subjects to read out the *Rainbow Passage*, a text commonly employed by researchers examining intonation patterns (for example: Brown et al., 1993; Brown et al., 2000; Linville, 2002; McHenry, 1999; Morris & Brown, 1994; Morris et al., 1995; Ramig, Countryman, Thompson, & Horii, 1995). Employing the *Rainbow Passage* as an

assessment task pre- to post-session is impractical due to the length of time required to carry this task through. However, in retrospect, it could have been employed pre- and post-program to measure the long term effects of treatment. Being able to compare the outcomes of this study with Haneishi's would have been more valuable, however, at the time that this study was designed, Haneishi's research had not yet been published. Future researchers should consider adopting the Rainbow Passage so that comparability between studies is more reliable. Nevertheless, a potential problem with the employment of the Rainbow Passage is that subjects might not have the residual language/reading skills to undertake this task post-trauma. Researchers should also bear this in mind.

The *VAMS*, although designed specifically for neurologically impaired people, was too abstract for some subjects in this study. Consequently, subjects scored inconsistently and with high variability. Some subjects reported a consistent flat affect while others reported polarities. It is unclear whether subjects found this task difficult or whether they had difficulty in identifying, describing and measuring their own mood states. Irrespective of the reasons for the unreliable data, this scale is not recommended for use in research.

The researcher selected a single phrase for analysis of the songs sung by each subject in this study. Subsequent analysis of the data indicated that this proved rather limiting because there was insufficient data to ascertain the subjects' song singing abilities. Further, the phrases in some subjects' song only contained two or three intervals, and in most cases, these intervals were limited to major and minor 2<sup>nds</sup> and 3<sup>rds</sup>. Therefore, there were limited opportunities for assessment of larger intervals within the song context. Further, the differences in interval composition of the song phrases between subjects meant that cross-case comparison of changes in accuracy during song singing could not be undertaken. While still maintaining subject song-choice, the program could also include one single song for analysis across cases to strengthen the study design by providing a consistent marker point and measure of change. This song should contain several small and large intervals and a wide vocal range, which may not be present in other songs. An example of a suitable song would be Happy Birthday, which is well-known cross culturally and contains a wide variety of intervals.

### ***Software analysis procedures***

The Multi-Speech™ software program was found to be valuable in analysing, as well as presenting a numerical and pictorial representation of the frequency data. Its drawback is its extreme sensitivity to processing any sounds or noise contained within the

signal. This became problematic when subjects' audio samples contained vocal material that was too low in intensity (decibel level) to be processed. To accommodate for this problem, the amplitude of the audio signal was increased, but in doing so, the intensity of any ambient noise or artefact sounds also increased. In these cases, the software program was not always able to discriminate between the subjects' voices and artefact sound and for this reason, some audio data was considered contaminated and discarded. Researchers analysing the data from a numerical perspective need to be aware of this possibility and always review the pictorial representation of the data to determine any obvious contaminations. Such contaminations were described in Figures 7, 9, 10 and 11.

One function of the software that was not utilised to its full potential was the pictorial representations of the song and sentence audio samples. As was noticed in the case studies, improvements in vocal control were illustrated in the song lyric contours, these improvements were not represented in the corresponding numerical analyses. In retrospect, the study could have allowed for more song phrases to be analysed in this way to establish how consistent such improvements were over time and whether these improvements were noticeable in other phrases. For example, the same phrase could have been analysed in this way for every session, not just for the four sessions selected for this study. This could illustrate the gradual changes in control but also the variability between sessions.

Building on this idea, selecting only one phrase for between-session comparisons is insufficient to verify improvement in vocal control. There is an element of chance present when limiting the analysis to only one phrase. Further, their control may have been better in some song phrases than in others so it would have provided a more comprehensive analysis of the subjects' abilities and improvements. Future research should consider taking greater advantage of the contour function when analysing vocal control, as well as increasing the number of song phrases analysed.

Similarly, pictorial representations of the sentence contours could have been analysed in this way. Bachorowski (1999) described that while the portrayal of mood states associated with high arousal (anger, happiness and fear) typically increases the  $F_0$ , and  $F_0$  variability, differentiation between these mood states may only be apparent when examining their contours. For example, the  $F_0$  decreases over time in the portrayal of anger whereas it increases over time in the portrayal of happiness. However, over the entire phrase, the  $F_0$  and  $F_0$  variability calculations may be similar for both mood states. On closer examination of the contour shapes, differences are likely to exist and be truer

representations of the moods they were trying to express. The employment of slope analysis in this study attempted to address this from a numerical perspective, however slope was only measured over two syllables and not over the entire phrase. Future researchers should consider studying the shapes of the sentence contours rather than relying on numerical analyses.

### **7.3 Applications and implications in clinical practice**

Clinical practice with neurologically impaired people is complex. Predicting responses to treatment may be difficult due to the individual nature of each client's brain injury combined with his personality and personal history. Further, the client's ability to cope with and adjust to such a sudden and dramatic change in life circumstance also influences therapy outcomes. Impairments in cognition have been found to impede therapy treatment, particularly impairments in concentration, attention, self-monitoring, insight and motivation, as well as displays of impulsive behaviour and perseverative tendencies. Singing songs is already a well-recognised intervention when working in neurorehabilitation. Songs provide an engaging structure potentially capable of overriding these cognitive impairments and thereby assisting clients to maximise therapy participation and facilitate early recovery. In addition to the work of Cohen and colleagues (Cohen, 1992; 1995; Cohen & Masse, 1993; Darrow & Cohen, 1991) described in Chapter 3, songs were regularly incorporated into work with coma patients (Bright & Signorelli, 1999; Kennelly & Edwards, 1997; Rosenfeld & Dun, 1999)<sup>39</sup>, in physical rehabilitation (Fields, 1954; Livingston, 1996; Lucia, 1987; Paul & Ramey, 2000; Staum, 1996) and communication rehabilitation (Baker, 2003; Baker, 2000; Magee, 1999a). The value of using songs in treatment of people with intonation impairments will be discussed in the following section along with other clinical implications arising from the interpretation of the results.

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<sup>39</sup> Interestingly, these three reports have all come from Australian music therapists, which may suggest song singing is considered an important aspect of music therapy for this country.

### 7.3.1 Referral criteria

The difficulties with perseveration and impulse control demonstrated by some subjects in this study indicate the need for clients to display necessary prerequisite cognitive skills before treatment will achieve maximum potential. This is especially the case when vocal skill exercises such as the PME are included as an integral part of the treatment or assessment process. The rehabilitation team need to be aware of these prerequisite requirements before referring clients for this treatment. It also implies that measuring improvements in vocal control with people who have interfering cognitive impairments is somewhat difficult and perhaps best assessed only during the singing of song phrases. Further, it is recommended that clients' rehabilitation programs address impairments in impulse control and perseveration prior to (or at the very least simultaneously with) commencing interventions that employ complex assessment tasks. Hanser (1999) emphasised the necessity to evaluate what prerequisite skills were required to successfully implement a program designed to address certain goals. In this case, clients need to have adequate concentration, attention, impulse control and an absence of perseveration before being able to participate in tasks such as the PME.

### 7.3.2 Intervention and expected therapy outcomes

Clinicians interested in applying the interventions described by this study can expect several outcomes to emerge. First, improvements in intonation are likely to occur, these enhancing clients' potential for more engaging and expressive conversations. Therefore, song singing is recommended as a treatment intervention appropriate for addressing intonation impairments in this population.

Familiarity and enjoyment of client-chosen songs provide a source of motivation to sustain clients' therapy participation. This is valuable given that poor motivation and concentration impede the therapy programs for people with TBI. The engagement evoked by singing songs is essential to maximise therapeutic outcomes.

In addition to their power to motivate, singing songs is an activity that often bypasses the neurological mechanisms required to complete other recreational and therapy tasks activities. The automatic recall of the words and melody provide opportunities for clients to sing (and therefore practice the targeted skills) with little thought required. This reduces the negative influences of poor initiation and perseveration, that are often

accentuated when clients begin to actively and consciously perform tasks. For example, clients with hemiparesis who have difficulty moving their arms can be seen lifting their hand to scratch their nose with a flow of movement and large elbow extension not achieved when instructed to perform the same task. In singing songs, clinicians can expect a *flowing* and enhanced performance in their clients' use of voice that is not achieved in other contexts such as pitch matching exercises. Therefore, the more familiar, well known and enjoyable a song is to a client, the more likely automatic recall will emerge and subsequently benefit the effects of the intervention.

This study highlighted that in extending the VR of subjects, there is a carry-over effect to enhanced intonation. As these correlations were highly significant, music therapy clinicians can predict that any extension in VR will affect the expressive potential of people with TBI who present with poor intonation. Given this, clinicians need to consider selecting songs that provide the greatest opportunity to extend VR and improve vocal control. This could be achieved through several different strategies. First, clinicians could select client-preferred songs that contain a wide pitch range. This would encourage clients to sing a combination of low and high pitches. Second, clinicians could select songs containing a wide variation in intervals including both small and large intervals. This would facilitate improvements in vocal control. Third, clinicians could modulate the key of songs to extend VR. Here, the melody line could be modulated up or down by a semitone, the modulations continuing to encourage the extension of VR. Nevertheless, the study also showed that the widening of VR was a gradual process. In supporting this process, clinicians could introduce a graded program whereby the range, melodic difficulty, and proportion of large intervals, was steadily increased. For example, songs with larger and more difficult intervals could gradually replace songs with stepwise motion. Introducing songs that are initially too melodically difficult for clients may result in increased client anxiety or feelings of failure, thus impeding their process of recovery.

An important finding from this study is that subjects' moods did not change in the direction expected from pre- to post-session. That is, subjects' became sadder, more afraid, more confused and more tired. It was proposed that this may have occurred because the lyrical themes and musical characteristics of the songs reflected their current mood states, which in turn, facilitated an increase in the intensity of their experienced emotions. Clinicians need to consider this when working with clients. Do their clients have sufficient support to manage these emotions at the post-session if such intense emotional experiences are evoked by the material of sessions? Clinicians should also be aware of the lyrical



content of the songs and not just their musical properties (which may be incongruent), as they have now been shown to have an impact on facilitating emotional change.

Evidence of the cumulative effects of treatment suggests that a period of treatment familiarisation is necessary before clients begin to display benefits of treatment. Clinicians need to factor this in to the design and length of the program and the evaluation of its effectiveness. Additionally, as subjects generally performed better during the pre-session assessments when compared with the post-session assessments, the immediate effects of treatment are not considered accurate measures of the effectiveness of treatment. Given these two points, clinicians should assess the long term benefits of treatment rather than the shorter term and immediate effects.

One of the reasons pre-session scores were higher than the post-session scores stem from the findings that subjects were more tired post-session. Participating in therapy is tiring and when this is coupled with the predisposition to fatigue typical of people with TBI, clinicians should not underestimate the propensity for fatigue in their clients. As subjects in this study reported increased fatigue following the 40-50 minute sessions, it is recommended that clinicians consider shorter (and then perhaps more frequent) sessions when working with this population. Alternately, subjects should be provided with rest periods to allow for physical and cognitive recovery.

While health professionals grounded in the medical model seek to support music therapy services where consistency in outcomes has been evaluated, rarely do two people with TBI present with the same clinical presentation and the same lesion sites and severity, particularly when diffuse head injury is involved. Therefore, it is not surprising that the subjects in this study responded differently to one another. When providing treatment to people with TBI, clinicians need to consider what constitutes *effective therapy* for each individual, taking into consideration individual differences when planning and evaluating the implementation of the intervention. For example, while three of the subjects within this study increased their VR, the extent and rate of the increase differed considerably between them. Differences in response may have arisen from several factors including: differences in lesion sites; the rate of overall recovery; levels of fatigue; and clients' emotional responses to trauma. Clinicians intending to adopt this treatment intervention need to modify it to accommodate for the individualised needs of each client.

### 7.3.3 Assessment and evaluation

#### *Pitch Matching Exercise*

Clinicians considering adopting the PME as a measurement tool need to ensure they have ample available time to process the data from this task. It is a time consuming process to record, download, cut, paste, code and then analyse this data. Several hours are required to process the data from a single session. Hence, it is not practical to analyse data at this level on a session by session basis. For effective time management, it would be more feasible to use this assessment as a baseline and reassessment tool rather than repeated on a frequent basis. The finding that clients with TBI have large fluctuations in performance supports the recommendation that frequent assessments are unhelpful. Second, clinicians need to be aware that the PME assessment is of little value for those clients who display perseveration and poor impulse control as their poor performance becomes a measure of these cognitive problems rather than a measure of poor ability to control the voice.

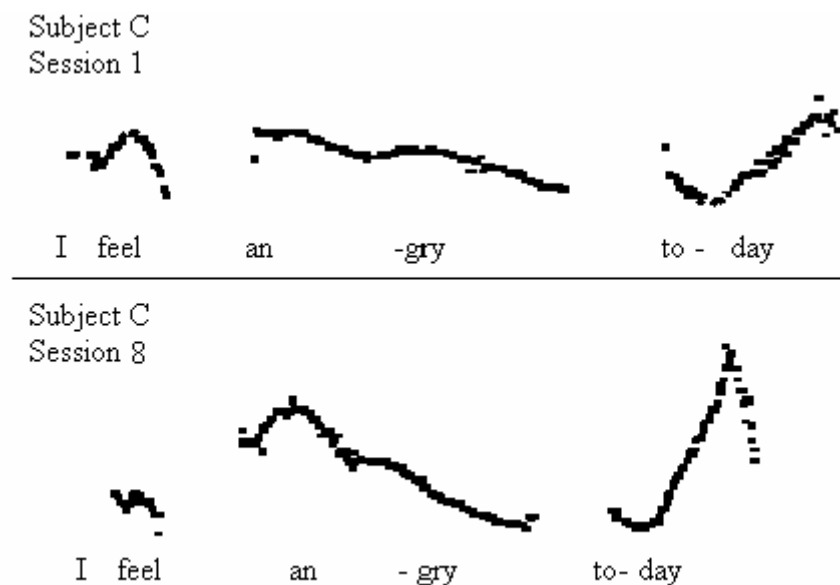
#### *Multi-Speech™ Software*

Despite the difficulties reported in 7.2.2 in processing and analysing the audio data in the Multi-Speech™ software program, it is valuable in measuring changes to  $F_0$ , SVS, slope, voice range and pitch control. It is able to measure subtle (but important) improvements in these vocal characteristics that may not be perceived by the human ear. Further, presenting the results of these analyses to the treatment team may be viewed as more scientific and therefore more convincing than the presentation of results from subjective assessments.

Clinicians intending to utilize this software should familiarise themselves with several procedures involved in order to obtain the most reliable analysis. First and foremost, the clinician should supply adequate recording equipment including a high quality, unidirectional microphone (preferably a headset), and digital recording (either DAT or mini-disc). Poor quality recording equipment will result in artefact noise, this significantly impairing the analysis of the data. Second, the sessions should be conducted in a quiet environment, preferably away from environmental sounds such as birds whose high frequency singing is easily picked up by the microphone. Interference by environmental noise can be minimised by ensuring the microphone is placed correctly on

the client's head. Third, clinicians should familiarise themselves with the techniques of cleaning contaminated audio – the functions built into the software such as pitch smoothing, but also other techniques such as limiting the frequency range to be analysed (to reflect the approximate pitch range of the client) and trimming the data where there is obvious interference. Contamination is normally illustrated by outlying values in the pictorial representations of the audio contours.

The software is also valuable in enabling the contours to be pictorially represented. The subtle differences, particularly in contour shape, are more clearly displayed in these representations than their corresponding numerical values, which in effect, take a mean for the entire audio, sample analysed. Further, the contours may be a more meaningful medium to communicate client improvements to the client, the client's family and the treatment team, than the numerical data computed by the program. For example, Figure 83 illustrates how subject C has increased the range of his voice from session one to session eight. This form of data may be more understandable than stating that the range of subject C's speech increased from five semitones to eight semitones.



**Figure 83. Sample comparison of data for communication of treatment outcomes**

### *Visual analog mood scale*

The difficulties encountered in obtaining reliable data for the VAMS were previously described (p.275). Therefore, the author does not recommend its use for clinical

or research purposes. A single bi-polar scale (happy-sad) may be more reliable than the VAMS, as utilised in other research projects (Haneishi, 2001; Nayak et al., 2000).

## 7.4 Conclusions and final thoughts

This was the first music therapy study to examine both immediate and long term treatment effects on the  $F_0$ , SVS and slope of people with TBI. It also attempted to understand the processes underlying these. Music therapy studies have previously explained improvements in functioning – in this case intonation - as a product of the recovery in neurological processing specific to the function under investigation. These recovery processes may include neuroplastic changes or the reconnection of damaged neural pathways (Baker & Roth, accepted for publication). It is taken as a given that the brain is the control station for all human behaviour. However, the brain is complex with many processes simultaneously active at any given moment. Much of the research had not considered what role mood and physiological states play in intonation during recovery. Humans are complex organisms and this study sought to link together some of these complex processes in explaining client recovery.

In returning to the initial research questions presented in Chapter 3 (3.9), the following statements summarise the findings for each question.

q.1 In what ways does the affective intonation contours ( $F_0$ , variability and slope) change in people with TBI?

The subjects with TBI in this study varied in the ways that their intonation contours changed in response to song singing intervention with some subjects increasing their  $F_0$ , variability and slope and others decreasing these. It appeared that the direction of change depended on the pre-injury characteristics of the speaker.

q.2a. Does a song-singing intervention facilitate changes in vocal range?

Subjects in this study demonstrated increased vocal range over the course of the program although the degree of increase differed between the subjects.

q.2b. Does a song-singing intervention facilitate changes in mood?

Several trends related to mood emerged from this study. Firstly, it appeared that singing songs that matched a subjects' mood intensified these feelings at that moment. Secondly, singing songs appeared to have a long term cathartic effect, which enhanced subjects' perceived feelings of happiness and decreased their feelings of sadness, fear, and confusion. In addition, singing songs had a long term effect in decreasing perceived feelings of tension and an immediate effect of increasing feelings of fatigue.

q.2c. Does a song-singing intervention facilitate changes in pitch control?

The results of this study were inconclusive in showing whether song singing facilitated improvements in pitch control. Some subjects improved but others did not.

q.3a. Do changes in intonation correlate with changes in vocal range?

The findings clearly showed that increases in vocal range correlated with increases in SVS and slope and decreases in  $F_0$  suggestive of a decrease in vocal fold tension and therefore enhanced vocal flexibility (q.3b).

q.3b. Do changes in intonation correlate with changes in mood?

Contrary to the direction suggested by the literature, the intensification of mood states had a reversed effect on intonation – that is, a decrease in the  $F_0$ , SVS and slope. Long term increases in positive feelings appeared to correspond with increases in  $F_0$ , SVS and slope.

q.3c. Do changes in intonation correlate with changes in pitch control?

Due to the high variability in subjects' pitch control, there was no evidence to suggest any correlation between pitch control and intonation.

q.4. Are people with TBI more expressive in communicating a range of mood states following a song singing program?

Song singing enhanced the subjects' ability to speak more expressively as evidenced by increases  $F_0$ , SVS and slope (although this only occurred in three of the four subjects). However, it is unclear as to whether they were better able to differentiate between the different emotions.

These new insights provide a starting point for further investigation into the complex processes underlying the recovery of intonation in people with TBI.

The longevity and development of the music therapy profession relies heavily on research developments, particularly those that illustrate functional outcomes which may reduce the cost of clients' long term care. This study contributes to the growing evidence that music therapy is effective in rehabilitating people with TBI. Publications and the communication of these findings to the wider medical community may contribute to raising awareness of what music therapy has to offer. Such awareness within the neurorehabilitation field may lead on to increased deployment of music therapy as a recognised intervention, more respect by the treatment team, and increases in interdisciplinary clinical work.

While music therapy and speech pathology programs tend to address similar client needs, reports of such interdisciplinary teamwork are rarely published (Baker, 2000; Baker 2003; Baker, submitted for publication; Kennelly et al., 2001; Lee & Baker, 1997). The efficacy of this singing program in re-establishing affective intonation patterns, vocal control, and a widened vocal range may lead to an enhanced awareness of what music therapy clinicians have to offer the speech pathology profession. This may lead to a larger incidence of interdisciplinary teamwork and potentially more effective treatment programs. Lee and Baker (1997) already describe the value in an interdisciplinary model of treatment whereby clients have fewer goals, these being addressed by several team members employing their own disciplinary treatment interventions.

The main findings summarised on p.300 assist clinicians in understanding the complexities of working with this population and what they can expect from treatment. Information regarding the long term and short-term effects is valuable as clinicians can be assured that negative post-sessions assessments are potentially linked to fatigue, a consequence of an outpouring of emotions, and not necessarily indicative of an inappropriate or ineffective intervention.

The profession can benefit from insights obtained here regarding the importance of carefully selecting appropriate song material. Familiarity and preference for songs is not sufficient criteria for selecting songs. Songs need to be evaluated according to their lyrical and musical properties, these perhaps matching the mood states of the clients at the time therapy is scheduled.

The concepts of catharsis, arousal, affect expression, fatigue and tension release, and their interrelationships as hypothesised earlier in this chapter (p.270-271) are important

in relation to the field of neurology and neuromusicology. To consider that neuroplastic changes were facilitated through the *repetition* of music therapy tasks, as a full explanation for the recovery process is insufficient as evidenced by the findings of this study. The neurological processes and what stimulates their activation appear to be much more complex than described by earlier music therapy and music psychology studies.

Most importantly, this research has potential benefits for the recovery of future clients with TBI. An understanding of the need for treatment familiarisation, for monitoring levels of fatigue and the necessity to consider the lyrical and musical factors when selecting songs, will inevitably result in maximising their therapy participation and therapeutic outcomes.

### ***Personal reflections***

In undertaking this research, I gained a new appreciation about the research process - being able to modify my research focus to a manageable size; selecting the most appropriate research design and assessment tasks; confronting the problems of lost or contaminated data; and working together with a research assistant and being able to place *trust* in her competence.

All researchers are faced with challenges when undertaking studies that involve large quantities of data. It is my impression from undertaking this research that such challenges are exacerbated when that data involves audio material. Managing over 5,000 audio files and their individual analysed results was at times overwhelming. It was a time consuming process to listen to it, cut the audio sample to obtain the relevant portions it, code and store it and then analyse each file and compile the results of each file in a larger central file.

After the analyses of the data were undertaken, I discovered that the findings were often in directions contrary to my expectations. It was personally difficult to then step back and try to question objectively why the results emerged in the way that they did. It required being able to *let go* of my expectations and accept the results for what they were. At the same time, while I tried to understand the root of these findings, I experienced exhilarating moments when new insights emerged.

The process of being able to immerse myself in the data at this level has been personally satisfying. I feel privileged to have had the opportunity to examine such small fragments of vocal data in depth and to try and conceptualise what is underlying the

treatment process. Even the possibility of analysing the musical material and attempting to connect its musical characteristics with the mood states of the subjects was interesting and rewarding. These are time consuming but pleasurable tasks that one does not often afford when in the role of a clinician.

During the course of my research, speech pathology clinicians and researchers connected with The University of Queensland, and the rehabilitation team at The Royal Children's Hospital, Brisbane, became aware of my research focus. More recently, I was invited to present my findings, which were positively received. This has stimulated their interest in the role of music and music therapy in treating clients with intonation problems and their support for this research focus to continue. The speech pathology research team at The University of Queensland recently invited me to present these findings at the World Congress in Speech Pathology in 2005. This affirms their respect for music therapists working in rehabilitation and their wish to strengthen the connections between the two disciplines.



## CHAPTER 8

### ENGLISH AND DANISH SUMMARIES

#### 8.1 English Summary

##### 8.1.1 Background information

The aim of this study was to examine the effects of a song-singing program on the affective speaking intonation of people with TBI who presented with monotonal voices. In addition, the study sought to understand the role that changes to voice range, vocal control and mood played in facilitating improvements in affective intonation.

Affective intonation refers to the melodic contour of the voice that typically reflects the mood state of the speaker (Perkins, Baran, and Gandour, 1996). Intonation contour is the term used to describe the overall shape of the rises and falls in pitch over time in a spoken phrase, without regard for the exact pitch intervals (Patel, Peretz, Tramo and Labreque 1998). These contours comprise of several components. First, pitch height often referred to as fundamental frequency ( $F_0$ ) describes the average frequency of the voice, the most frequently occurring pitch. Second, frequency range refers to the entire range of frequencies used over a given intonation contour. They can be described as small, medium or large. Third, slope describes the rate of change in the  $F_0$  at the syllable, word, phrase or sentence level. Here, pitch changes that occur rapidly are described as having steep slopes, whereas those that occur slowly have gradual or flat slopes. Finally, frequency variation termed standardised variability score (SVS) refers to the variability present in the intonation contour. Low levels of pitch variability are indicative of a flat and monotonal speaking voice (Wymer, Lindman, and Booksh, 2002).

While each person displays idiosyncratic intonation patterns, studies have established that for affective intonation, stereotypical patterns exist across cultures (Mozziconacci and Hermes, 1997; Murray and Arnott, 1993). For example, anger is typically expressed with a high  $F_0$ , large SVS, steep slopes and wide pitch ranges.

Following traumatic brain injury, impairment in expressing affective intonation may result. Only a few studies have attempted to determine the neurological mechanisms involved

in affective intonation with conflicting results reported. Involvement of the left hemisphere (LH) and right hemisphere (RH) (Joanette, Goulet, and Hannequin, 1990), the combination of RH and basal ganglia (Cohen, Riccio, and Flannery 1994; Gandour et al., 1997), the basal ganglia without LH or RH involvement, and in the prefrontal areas (Cancilliere and Kertsz, 1990) have been all be shown to have involvement in the process.

While intonation is largely the product of a series of neurological processes which set the vocal mechanism into action, it is also the product of more complex and holistic processes. For example, disruption to the body's balance can predispose the highly sensitive laryngeal muscles to tension, fatigue, rigidity and constriction (Aronson, 1990; Bunch, 1997; Newham, 1999). Fatigue in particular, greatly affects vocal performance (Kitch and Oates, 1994; Welham and MacLagan, 2003) and is a symptom typical of people with traumatic brain injury (Oddy, Coughlan, Tyerman, and Jenkins, 1985).

The emotional state of the speaker is also said to have an important influence on the voice. For example, people with mood disorders typically communicate with intonation that is low in pitch height and very slow (Alpert, Pouget, and Silva, 2001; Garcia-Toro, Talavera, Saiz-Ruiz, and Gonzalez, 2000; Naarding, van den Broek, Wielaert and van Harskamp, 2003).

There has been minimal research focusing on the music therapy treatment of impairments in speaking intonation. Only two experimental studies (Cohen and Masse, 1993; Darrow and Starmer, 1986) and a limited number of case studies or anecdotal reports (Cohen, 1992; 1995; Darrow and Cohen, 1991; Haneishi, 2001; (Kennelly, Hamilton, and Cross, 2001; Livingston, 1996; Zoller, 1991) have been documented in the literature. Several discrepancies were evident in their research findings. Some studies noted no changes in the  $F_0$  (Cohen 1995), some found increases in the  $F_0$  (Haneishi, 2001), while others noted a decrease in the  $F_0$  (Darrow and Starmer, 1986). Cohen (1992) reported that some of her subjects increased their  $F_0$  while other subjects'  $F_0$  decreased. The  $F_0$  variability increased in all studies reported (Cohen, 1992; Darrow and Starmer, 1986; Haneishi, 2001) although in Cohen's study, only half of the experimental group displayed increases in  $F_0$  variability. In all cases, the use of familiar songs was an integral part of the treatment program.

Several of these music therapy studies have sought to explain the outcomes of treatment from neurological perspectives. There has been a distinct lack of studies addressing intonation recovery from a more holistic perspective.

### 8.1.2 Method

#### *Design*

A multiple case study design (four subjects) was adopted to explore the changing responses within-subjects and between subjects as a consequence of their participation in a music therapy program. Data was collected pre to post-session and over time to establish immediate and long term treatment effects. In addition to a presentation of case studies, the data for all four subjects was pooled and the results presented to identify common patterns of response. Fifteen individual music therapy sessions were carried out for each subject, two-three times per week over a five-eight week period.

#### *Participants*

Four male participants aged between 24 and 29 years of age ( $M=26.5$  years) were eligible and subsequently participated in the study. All subjects presented with impaired intonation, in particular, poor use of  $F_0$ , SVS and slope, to convey a range of emotions.

#### *Treatment sessions and data collection*

The treatment sessions comprised pre and post-session assessments and the singing of three subject-selected songs. The same three songs were used each session for the entire treatment program. Audio data were collected pre and post-session by recording the subjects': speaking of affective sentences; ability to sing high and low pitched notes; and ability to reproduce given intervals. A visual analog mood scale (VAMS, Stern, 1997) was also employed to collect data on pre and post-session mood states. Recordings of the subjects singing their chosen songs were also made during each session.

The intonation sentence task required the subject to intone different emotions into four sentences conveying four different moods (happy, sad, angry and afraid). This data was collected to evaluate changes to subjects'  $F_0$ , SVS and slope while expressing these different emotions. The pitch matching exercise (PME) required subjects to sing back ten-randomly ordered intervals ranging from a minor 2<sup>nd</sup> to a major 7<sup>th</sup> after hearing them played on a CD.

### ***Data Analysis***

The audio data was imported into a personal computer and the data analysed using the software program Multi-speech model 3700™. The  $F_0$  was automatically calculated by the program and the SVS was calculated by converting the  $F_0$  standard deviation scores given by the program into semitone measures. Slope was calculated by dividing the difference between the highest and lowest frequency (of two-syllables) by the difference in time and then converting this score into a score of the speed of semitone change per second.

Accuracy in singing intervals (both within songs and in the PME) and voice range was also calculated using the software. In addition, one phrase from one song was selected for each subject for further analysis. This audio data was processed by the software and a pictorial representation of the contour produced. These contours were compared overtime to determine any improvements in vocal control not able to be represented by the numerical data. VAMS were assessed as per standardised procedure.

### **8.1.3 Results**

#### ***Intonation Measures***

Results of the case studies and pooled data indicate that song singing had an immediate effect and long term effect on the various intonation measures. Generally, the subjects responded idiosyncratically, with the direction and degree of change varying between subjects. Immediate effects (pre to post-session) were in the direction contrary to that hypothesised – that is,  $F_0$ , SVS and slope measures were lower at the post-session. This suggests that subjects speaking post-session were less expressive, with a lower pitch and more monotonal vocal style.

Long term effects of treatment were in the direction expected although levels of significance were not achieved. Here,  $F_0$ , SVS and slope measures increased over the course of treatment indicating that the subjects were more expressive. A lack of significance was influenced by one subject's responses that were strongly in an opposite direction to that of the other subjects, which might be interpreted as a negative response. However his responses moved towards his pre-trauma vocal style and therefore can be interpreted as positive responses.

Cumulative effects of treatment were evident in that the treatment had a stronger post-session effect during the latter part of the program.

### ***Voice Range Measures***

The long term effect of treatment on subjects' voice range was large with the mean increase of voice range being 1.79 semitones. Immediate effects of treatment were again in a negative direction although the decrease in range was small (0.38 semitones). Between-subject differences were again evident.

### ***Mood states***

There were no significant long term effects of treatment on mood due to significant between-subject differences. Further, responses tended to be polarised either consistently reporting a flat affect across all mood descriptors, or reporting large swings from one mood state to another. Effect size calculations indicated that in the long term, subjects became happier, less afraid, less confused, less sad but also more tired. Conversely, immediate effects of treatment indicated that subjects became more afraid, more angry, more sad, and more tired post-session. This result was in the direction contrary to that hypothesised.

### ***Pitch Matching Exercises***

Results indicated that there were differences in the abilities of subjects to sing back intervals played to them and differences between subjects with regard to long term changes in pitch matching accuracy.

Results concerning the specific intervals show that there were differences in accuracy between the different intervals and that subjects varied significantly in which intervals they were able to sing most accurately. Calculations of deviations away from accurate interval reproduction show that the perfect 5<sup>th</sup> was the most accurately produced interval. The smaller intervals (those less than or equal to a perfect 4<sup>th</sup>) were also more accurately sung when compared with the larger and more difficult intervals (such as the augmented 4<sup>th</sup>, major and minor 6<sup>th</sup> and 7<sup>th</sup>).

### ***Pitch Matching in Song Phrases***

Accuracy in producing intervals presented in song phrases again were different between subjects. Similarly, differences in accuracy between intervals were also found. Some subjects demonstrated long term improvements in singing accuracy and other subjects did not. As was the case with the PME, the smaller intervals (major and minor 2<sup>nds</sup>) were more accurately produced than the larger intervals.

When the accuracy in producing intervals in songs was compared with the accuracy in PME, context was shown to be important. Here the intervals were sung better within the song context when compared with the pitch matching exercise.

### ***Correlations between intonation measures and other variables***

When voice range and mood were correlated with F<sub>0</sub>, SVS and slope, several significant correlations were found (eight out of 12 correlations were highly significant –  $p < .01$ ). First, voice range was negatively correlated with the F<sub>0</sub>, indicating that as the voice range increased, the F<sub>0</sub> decreased. Conversely, as the voice range increased, the SVS and slope also increased. This shows that there is a direct link between increases in vocal range and increases in speaking expressivity as a consequence of the treatment.

Correlations between mood states and the intonation measures showed several negative correlations, particularly with SVS. This means that when high scores on a VAMS were recorded by the subjects (increase affect), they tended to say the sentence describing this mood (or a related mood) in a more monotonal way, with less variability in the frequency of their voice.

## **8.1.4 Discussion**

### ***Long term effects***

The results of this study show that participation in the singing of songs had the long term effect of enhancing the expressive speaking potential in people who have TBI. Generally subjects became more able to manipulate intonation components - F<sub>0</sub>, SVS and slope - in order to express a range of emotions. The F<sub>0</sub> was the component to be the most positively affected while the slope was the least affected by the treatment. Levels of significance in long term effects were not found as a consequence of one subject's strong response in the direction

opposite to the other three cases. However, in this case, it was established that this subject was returning to a pre-trauma speaking style.

An important finding was that there were strong correlations between increases in voice range and improvements in intonation components. The negative correlations between the  $F_0$  and voice range and the positive correlations between the SVS, slope and voice range suggest that the vocal apparatus was more relaxed in the long term allowing the vocal folds greater flexibility and elasticity required to achieve expressive intonation patterns. Such effects of song singing indicate that the act of singing decreases vocal fold tension.

Another important finding was the long term increase in feelings of happiness and the decrease in feelings fear, confusion and sadness. These findings may explain the long term enhancement of expressive potential observed in the subjects. Here, the act of singing may have had a positive long term effect on mood which may account for such improvements. The finding that the subjects reported experiencing a long term decrease in tension supports this notion.

Long term improvements in vocal control were not found in the responses of subjects during the pitch matching exercise or during the singing of song phrases. However, subjects' singing was performed more accurately during the singing of song phrases. Cognitive impairments such as impulse control, perseveration, poor concentration and poor direction following explain this finding.

### ***Immediate-effects***

The immediate effects of treatment show that performance in intonation measures decreased post-session. Here, subjects spoke in a lower pitched and more monotonal voice. This finding was in the direction contrary to that hypothesised. This same trend emerged in the other data collected pre and post-session. Voice range was narrower post-session and the negative mood states of anger, fear, sadness and fatigue increased post-session. The poorer post-session performance may be understood by the possibility that the singing of songs may have raised the subjects' awareness of negative emotions and in doing so intensified their experience of them leading to increased feelings of sadness, fear, anger and fatigue post-session. In these cases, subjects were not able to perform in the intonation, voice range and pitch matching tasks to the same level as was performed pre-session due to them being

preoccupied with their distressing emotional states. The lyrical content and musical characteristics of the songs may explain why music had the effect of increasing self-reports of negative emotions. Here, most of the songs employed in the program conveyed the emotion of sadness.

While the rehabilitation team might consider this as having negative implications, acknowledgment or an awareness of these emotions allows people with TBI to address and process their situation, this being a vital step towards acceptance.

### ***Limitations of the study***

Selection criteria did not attempt to control for variations in the cognitive abilities and consequently, some subjects in the study presented with impairments which inhibited their ability to perform in the pre and post-session tasks. Therefore, poor performance in these tasks became a reflection of cognitive deficits rather than demonstrating impairments (and therefore improvements) in the variables under investigation.

The repetition of the same three songs may have limited the redevelopment of vocal flexibility. Introducing new musical material each session provides a continuous stream of varied melodic lines – differing in tempo, interval ordering, mood, etc. Variation is more likely to encourage vocal fold flexibility. Therefore, it is probable that in not varying the song repertoire, the maximum therapeutic outcomes were limited.

Subjects within this study presented themselves within a *testing* situation. Consequently, there was a possibility that subjects may have manipulated their responses within the pre and post-session tasks in order to consciously or unconsciously influence results.

Another limitation of this study was that during the pre-session and post-session tasks, subjects were asked to artificially inflect an emotion into a sentence. It was underestimated how difficult this task would be for subjects, particularly as they were asked to intone emotions that they may not have been experiencing. In addition, the *VAMS*, although designed specifically for neurologically impaired people, was too abstract for some subjects in this study. Consequently, subjects scored inconsistently and with high variability. Some subjects reported a consistently flat affect while others reported polarities. It is unclear whether subjects found this task difficult or whether they had difficulty in identifying, describing and



measuring their own mood states. Irrespective of the reasons for the unreliable data, this scale is not recommended for use in this type of research.

### ***Implications in clinical practice***

Clinicians interested in applying song singing interventions with people who have TBI and present with impairments in intonation, can expect several outcomes to emerge. First, improvements in intonation are likely to occur, these enhancing clients' potential for more engaging and expressive conversations. Therefore, song singing is recommended as a treatment intervention appropriate for addressing intonation impairments in this population.

Singing songs is an activity that often bypasses the thought mechanisms required to complete other activities. In singing songs, clinicians can expect a *flow* and enhanced performance in their clients' use of voice, this not achieved in other contexts such as in pitch matching exercises. This reduces the negative influences of poor initiation and the presence of perseveration, which are often accentuated when clients begin to actively and consciously perform tasks.

Clinicians can expect significant increases in voice range in a short-term program with a carry-over effect to enhanced intonation. To achieve this, clinicians need to consider selecting songs that provide the greatest opportunity to extend voice range and improve vocal control. Clinicians should introduce a graded program whereby the range, melodic difficulty, and proportion of large intervals contained within a varied song program, was steadily increased.

Evidence of the cumulative effects of treatment suggests that a period of treatment familiarisation is necessary before clients begin to display benefits of treatment. Clinicians need to consider this when designing the length of the program and the evaluation of its effectiveness. Additionally, as subjects generally performed better during the pre-session assessments when compared with the post-session assessments, the immediate effects of treatment were not considered accurate measures of the effectiveness of treatment. Given these two points, clinicians should assess the long term benefits of treatment rather than the shorter term and immediate effects.

One of the reasons pre-session scores were higher than the post-session scores stem from the findings that subjects were more tired post-session. Participating in therapy is tiring

and when this is coupled with the predisposition to fatigue typical of people with TBI, clinicians need to be aware not to underestimate the propensity for fatigue in their clients. As subjects in this study reported increased fatigue following the 40-50 minute sessions, it is recommended that clinicians consider shorter (and then perhaps more frequent) sessions when working with this population. Alternatively, subjects should be provided with rest periods to allow for physical and cognitive recovery.

The finding that there were high degrees of variability between subjects in the way they responded to treatment and their treatment outcomes, have clinical implications that music therapy practitioners need to consider. Because of the idiosyncratic nature of subject-response to treatment, clinicians need to be aware that all therapy objectives, method and strategies to ensure maximum client participation and outcomes, will need to be individualised. This is particularly important when cognitive impairment impact on treatment to a large extent.

### 8.1.5 References

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## **8.2 Dansk resumé**

### **8.2.1 Baggrundsinformation**

Målet med dette studie er at undersøge effekten af et behandlingsprogram bestående af sange på den affektive intonation i talen hos mennesker med TBI (Traumatic Brain Injury), der ofte har en monoton stemmeføring. Desuden forsøger undersøgelsen at forstå den rolle, som forandringer i stemmens rækkevidde (voice range), den vokale kontrol og klienternes emotionelle tilstand (mood) spiller i forhold til at facilitere forbedring i den affektive intonation.

Affektiv intonation refererer til stemmens melodiske konturer, der typisk reflekterer den talendes emotionelle tilstand (Perkins, Baran, og Gandour, 1996). Intonationens konturer er et begreb, der beskriver den samlede form af stigning og fald i tonehøjden i en talt frase/sætning uden at tage hensyn til det eksakte tonale interval (pitch interval) (Patel, Peretz, Tramo og Labreque 1998). Disse konturer består af adskillige komponenter: For det første tonehøjde, der ofte refererer til den fundamentale frekvens ( $F_0$ ).  $F_0$  beskriver stemmens gennemsnitlige frekvens, også kaldet den oftest forekommende tonehøjde. For det andet frekvensrækkevidden, der refererer til den samlede rækkevidde af frekvenser anvendt i en given intonationskontur. Denne kan beskrives som lille, mellem eller stor. For det tredje hældningsgraden (slope), der beskriver forandringen af  $F_0$  på stavelses-, ord, frase- og sætningsniveau. Her beskrives forandringer i tonehøjde, der sker hurtigt som havende en stejl hældning, mens de forandringer, der sker langsomt, beskrives som havende en gradvis eller flad hældning. Endelig er der begrebet frekvensvariation, der benævnes som en standardiseret variabilitets score (SVS). SVS refererer til den variabilitet, der er til stede i intonationskonturerne. Lavt niveau i tonehøjdevariabilitet indikerer en flad og monoton talestemme. (Wymer, Lindman og Booksh, 2002).

Mens enhver person fremviser idiosynkratiske intonationsmønstre, har studier vist, at stereotypiske mønstre for affektiv intonation eksisterer på tværs af forskellige kulturer (Mozziconacci og Hermes, 1997; Murray og Arnott, 1993). Vrede er for eksempel typisk udtrykt ved en høj  $F_0$ , stor SVS, stejl hældning og en stor tonerækkevidde.

Traumatisk hjerneskade (TBI) medfører ofte en svækkelse af evnen til at udtrykke affektiv intonation. Der er kun få studier, der har forsøgt at bestemme de neurologiske mekanismer, som er involveret i affektiv intonation, og disse fremviser modstridende resultater. Alle de følgende områder i hjernen har vist sig at være involveret i processen: Den venstre hemisfære (VH) og den højre hemisfære (HH) (Joanette, Goulet og Hannequin, 1990); kombinationen af HH og basale ganglier (Cohen, Riccio og Flannery 1994; Gandour et al., 1997); de basale ganglier uden VH og HH og de præfrontale områder (Cancilliere og Kertsz, 1990).

Intonation er hovedsagelig et produkt af en serie af neurologiske processer, der sætter den vokale mekanisme i funktion, men intonation er også et produkt af mere komplekse og holistiske neurologiske processer. For eksempel kan forstyrrelse af kroppens balance medføre,

at den meget sensitive laryngale muskel bliver prædisponeret over for spænding, træthed, rigiditet og sammentrækning (Aronson, 1990; Bunch, 1997; Newham, 1999). Specielt træthed påvirker stemmens funktion (Kitch og Oates, 1994; Welham og MacLagan, 2003) og udgør et typisk symptom for personer med traumatisk hjerneskade. (Oddy, Coughlan, Tyerman og Jenkins, 1985).

Den emotionelle tilstand (mood state) hos den talende person siges også at have indflydelse på personens stemme. For eksempel kommunikerer personer med affektive forstyrrelser typisk ved at intonere med lav tonehøjde og meget langsomt. (Alpert, Pouget og Silva, 2001; Garcia-Toro, Talavera, Saiz-Ruiz og Gonzalez, 2000; Naarding, van den Broek, Wielaert og van Harskamp, 2003).

Der er kun foretaget begrænset forskning med fokus på musikterapibehandling af beskadigelse af intonation i tale. I litteraturen findes der kun to eksperimentale studier (Cohen og Masse, 1993; Darrow og Starmer, 1986) og et begrænset antal casestudier og anekdotiske rapporter. (Cohen, 1992; 1995; Darrow og Cohen, 1991; Haneishi, 2001; (Kennelly, Hamilton og Cross, 2001; Livingston, 1996; Zoller, 1991). Der er flere tydelige uoverensstemmelser i deres forskningsmæssige fund. Nogle studier finder ingen forandring i  $F_0$  (Cohen 1995), nogle fund viser en øgning i  $F_0$  (Haneishi, 2001), mens andre noterer et fald i  $F_0$  (Darrow og Starmer, 1986). Cohen (1992) rapporterer, at nogle individer øger deres  $F_0$ , mens andre individers  $F_0$  mindskes. Variabiliteten i  $F_0$  øges i alle rapporterede studier. (Cohen, 1992; Darrow og Starmer, 1986; Haneishi, 2001) selvom kun halvdelen af den eksperimentale gruppen i Cohens studie øgede deres  $F_0$ -variabilitet. I alle tilfælde var anvendelse af kendte sange en integreret del af behandlings- programmet.

En række musikterapiudier har forsøgt at forklare resultatet af behandlingen ud fra et neurologisk perspektiv. Der er en udpræget mangel på studier, der har undersøgt generhvervelsen af intonationsevnen ud fra et mere holistisk perspektiv.

### **8.2.2 Metode**

#### ***Design***

Et multiple case design (fire individer) anvendtes i undersøgelsen. De fire individer blev undersøgt i forhold til deres individuelle (within-subjects) forandring som følge af deres

deltagelse i musikterapien og i forhold til forandringen imellem deltagerne. Data blev indsamlet ved hver præ- og post-session og over tid med det formål at kunne vurdere dels den umiddelbare effekt, og dels effekten af hele behandlingsforløbet. Ud over gennemgangen af de enkelte forløb, blev data fra alle fire individer blandet sammen og analyseret med det formål at identificere mulige fælles responsmønstre. Femten individuelle musikterapisessioner blev udført med hvert individ, to til tre gange om ugen over en fire-otte ugers periode.

### ***Deltagerne***

Deltagerne var fire mand i alderen fra 24 til 29 år ( $M=26.5$  år), der var tilgængelige og som indvilligede i at deltage i undersøgelsen. Alle individer havde beskadiget intonation, specielt ringe brug af  $F_0$ , SVS og hældning, i deres tilkendegivelse af en række følelser.

### ***Behandlingsramme og dataindsamling***

En behandlingssession indbefattede både præ- og postsession-assessment og gennemsyngning af tre sange valgt af individerne selv. De samme tre sange blev anvendt i hver behandlingssession gennem hele behandlingsforløbet. Følgende audiodata blev optaget og indsamlet i præ- og postsessionerne: Individernes udtale af sætninger med affektivt indhold, evnen til at synge høje og lave toner, samt evnen til at reproducere givne tonale intervaller. Desuden blev en visuel analog stemningsskala (mood scale) (VAMS, Stern, 1997) anvendt til at indsamle data om individernes emotionelle tilstand i præ- og postsessionerne. Optagelse af individernes gennemsyngning af deres valgte sange blev også gjort i hver session.

Intonationsopgaven krævede, at hvert subjekt skulle intonere fire forskellige følelser (glæde, ked af det, had, vrede og frygt) og overføre dem til en af hver følgende fire sætninger, der hver udtrykte den givne følelse. Disse data blev indsamlet for at kunne evaluere forandring i individernes  $F_0$ , SVS og hældningsgrad, mens de udtrykte disse forskellige følelser. Øvelserne med matchning af tonehøjde (TMØ) krævede, at individerne skulle eftersynge ti tilfældigt ordnede intervaller strækkende sig fra en lille sekund til en maj 7, som de lyttede til på en CD.

### ***Data Analyse***

Audiodata blev computeranalyseret ved hjælp af programmet Multi-speech model 3700™.  $F_0$  blev automatisk udregnet, og SVS blev udregnet ved at omregne standartafvigelsen af  $F_0$  til en semitonemåleenhed. Hædningsgraden blev udregnet ved at dividere forskellen mellem den højeste og den laveste frekvens (af to stavelser) med forskellen i tid for derefter at konvertere dette tal til ændringen af talte semitoner pr. sekund.

Nøjagtighed i gengivelse af tonale intervaller (både i sangene og TMØ) og stemmens rækkevidde blev også udregnet ved hjælp af dette program. Desuden blev én sang udvalgt fra hvert individ til en grundigere analyse. Disse audiodata blev behandlet på computer, og grafiske afbildninger af konturer blev produceret. Disse konturer blev sammenlignet over tid med henblik på identifikation af enhver forbedring i den vokale kontrol, der ikke kunne iagttages i de numeriske data. VAMS blev vurderet ud fra en standartprocedurer.

### **8.2.3 Resultater**

#### ***Intonationsmål***

Resultaterne af casestudierne og sammenligningen af data indikerer, at anvendelse af sange har en umiddelbar effekt på adskillige intonationsmål. Generelt responderede individerne idiosynkratisk i forhold til grad og retning af forandring. Forandringen imellem individerne varierede. Den umiddelbare effekt (præ- til post-session) var i modsat retning af den fremsatte hypotese – dvs. at målene  $F_0$ , SVS og hædningsgrad var lavere i postsessionen end i præsessionen. Dette antyder, at individernes tale i postsessionerne var mindre udtryksfuld, med lavere tonehøjde og havde en mere monoton vokal stil.

Effekten af behandlingen over tid (long term) var i retning af det forventede, selvom resultaterne dog ikke var signifikante. Her blev målene  $F_0$ , SVS og hædningsgrad øget i løbet af behandlingen, hvilket indikerer, at individernes talestemme blev mere udtryksfuld. Mangel på signifikans blev influeret af et enkelt individs respons, der stod i stærk kontrast til de øvrige individers respons. Dette kan fortolkes som en negativ respons, men personen bevægede sig i løbet af behandlingen imod sin præ-traumatiske vokale stil, hvilket derfor tolkes således, at personen responderede positivt på behandlingen.

Den akkumulerede effekt af behandlingen blev tydelig, idet resultaterne af post-sessionerne senere i behandlingen blev bedre i løbet af programmet.



***Mål af stemmens rækkevidde***

Effekten af behandlingen over tid af individernes stemmes rækkevidde var stor med en gennemsnitlig forøgelse af stemmerækkevidden på 1.79 semitoner. Den umiddelbare effekt af behandlingen var igen ikke som ventet, selvom formindskelsen af rækkevidden var lille (0.38 semitoner). Forskellen imellem individerne var meget significant.

***Emotionel tilstand***

Der var ingen signifikant effekt af behandlingen over tid på følelsestilstanden på grund af forskellen i mellem de enkelte individer respons. Videre tenderede respons fra individerne til at polarisere sig således, at individerne enten konsistent rapporterede om en lav følelse af intensitet i alle følelsesindikatorer eller derved, at individerne rapporterede store udsving fra en følelsestilstand til en anden. "Effekt size" beregninger af effekten over tid indikerer, at individerne bliver gladere, mindre bange, mindre forvirrede, mindre kede af det, men også mere vrede, mere kede af det og mere trætte i post sessionerne. Dette resultat er modsat retning af det forventede.

***ToneMatchingsØvelse (TMØ)***

Resultatet indikerer, at der var forskelle i individernes evne til at eftersynge intervaller spillet for dem og forskel mellem individernes forandring med hensyn til effekten over tid af nøjagtighed i evnen til at eftersynge toner.

Resultaterne vedrørende de specifikke intervaller viser, at der var forskelle mellem de forskellige intervaller, og at individerne varierede meget i deres evne til at synge mest rent. Beregninger viser, at afvigelsen væk fra den akkurate intervalgentagelse var mindst ved kvinten, der var det interval, der blev gengivet mest nøjagtigt. De mindre intervaller (fra en kvart og ned efter) blev også sunget mere rent sammenlignet med store eller mere vanskelige intervaller som tritonus, stor og lille 6 og 7.

***Tonematching i sangfraser***

Nøjagtigheden i at gengive intervaller præsenteret i sange var igen signifikant forskellig imellem individerne. Ligeledes blev der også fundet signifikante forskelle i

nøjagtigheden imellem intervallerne. Der var ingen forbedring (effekt over tid) i evnen til at synge rent, da nogle individer demonstrerede fremskridt, mens andre ikke gjorde. Som det var tilfældet med TMØ, blev de mindre intervaller (stor og lille tert) gengivet mere præcist end de større intervaller.

Nøjagtigheden i at gengive intervaller i sange blev sammenlignet med nøjagtigheden i TMØ, og frembød et signifikant fund; i det at intervallerne blev sunget mere rent, når de blev udført i en sang frem for i en øvelse (TMØ).

### ***Korrelationen mellem intonations- og andre variable***

Når stemmens rækkevidde og emotionelle udtryk blev korreleret med  $F_0$ , SVS og hældningsgrad, viste adskillige signifikante korrelationer sig (otte ud af tolv korrelationer var meget signifikante). For det første var stemmens rækkevidde negativt korreleret med  $F_0$ , hvilket indikerer, at når stemmens rækkevidde øges, så falder  $F_0$ . Modsat viste det sig, at når stemmens rækkevidde øges, øges også SVS og hældningsgraden. Dette viser, at der er en direkte sammenhæng mellem forøgelse af stemmens rækkevidde og forbedring af stemmens ekspressivitet, som er en konsekvens af behandlingen.

Korrelationen mellem den emotionelle tilstand og de anvendte intonationsvariable viser adskillige negative korrelationer, specielt SVS. Dette betyder, at når et individ scorer højt på en VAMS (større affekt), tenderer de samtidig til at udtale de sætninger, der beskriver denne følelse (eller andre følelser) på en mere monoton måde, dvs. med mindre variation i stemmens frekvens.

## **8.2.4 Diskussion**

### ***Effekt over tid***

Resultatet af denne undersøgelse viser, at sange som behandlingsintervention havde en langsigtet effekt på talens ekspressive potentiale for individer med TBI. Generelt blev individerne bedre i stand til at manipulere intonationens komponenter -  $F_0$ , SVS og hældningsgrad – når de søgte at udtrykke en række af følelser.  $F_0$  var den variabel, der blev mest positivt påvirket, mens hældningsgraden blev mindst påvirket af behandlingen. Den langsigtede effekt viste sig dog ikke signifikant, idet et enkelt individ responderede i modsat

retning af de tre øvrige individer. Ikke desto mindre blev det i dette tilfælde klart, at individet var ved at vende tilbage til sin præ-traumatiske talemåde.

Et vigtig fund var en stærk korrelation mellem forøgelse af stemmens rækkevidde og forbedring i intonationsvariable. Den negative korrelation mellem  $F_0$  og stemmens rækkevidde og den positive korrelation mellem SVS, hælningsgrad og stemmens rækkevidde antyder, at det vokale apparat blev mere afslappet set over tid, hvilket tillader stemmelæberne større fleksibilitet og elasticitet i forsøget på at erhverve ekspressive intonationsmønstre. En sådan effekt af at synge indikerer, at denne aktivitet mindsker spændingen i stemmelæberne.

Et andet vigtigt fund var, at følelsen af glæde på lang sigt blev forøget, mens følelsen af angst, forvirring og sorg blev formindsket. Disse fund kan muligvis forklare det forstørrede ekspressive potentiale hos individerne, der observeres, når forløbet ses i sin helhed. Den registrerede positive forandring på individernes humør, der iagttages når forløbet ses i sin helhed, kan måske forklares ved, at det at synge har denne effekt. Det, at individerne beskriver oplevelsen af mindre spænding i løbet af behandlingen, støtter denne opfattelse.

Signifikante forbedringer af den vokale kontrol over tid blev hverken fundet i data fra individernes tone-matchnings-øvelser eller i deres af syngning af fraser. Men individernes fremførelse var mere nøjagtig, når de sang sange. Kognitiv svækkelse, såsom f.eks. dårlig impulskontrol, perseveration (at gentage en handling ufrivilligt), koncentrationsbesvær og dårlig evne til at følge instruktioner, forklarer hvorfor disse individer har vanskeligt ved at udføre disse øvelser.

### ***Umiddelbar effekt***

Den umiddelbare effekt af behandlingen vurderet ud fra intonationsvariable viser, at intonationsevnen daler i post-sessionen. Her talte individerne i en lavere tonehøjde og med mere monoton stemmeføring. Dette fund står i direkte modsætning til det ventede (hypotesen). Den samme tendens fremkommer i andre data samlet i præ- og postsessionerne. Stemmens rækkevidde blive mindre i postsessionen, og de negative sindstilstande som vrede, frygt, sorg og træthed var ligeledes forøget i postsessionen. Den ringe formåen i post-sessionerne kan muligvis forklares ved at afsyngning af sange har øget individernes opmærksomhed på negative følelser og som følge deraf har intensiveret oplevelsen af disse følelser. Dette medfører en øget oplevelse af ked af det, frygt og træthed i postsessionerne. I dette

tilfælde var individerne ikke i stand til at intonere, have samme vokale rækkevidde og synge rent på same niveau som i præ-sessionerne, når de skulle udføre opgaverne. Dette antages at skyldes, at de er opfyldt af deres forstyrrende emotionelle tilstand. Sangenes lyriske indhold og musikalske karakteristika kan forklare den forøgede selvrapportering af negative følelser. I dette behandlingsprogram omhandlede de fleste af sangene, følelsen af ked af det/hed/sorg.

Det er muligt, at dette umiddelbare udbytte af behandlingsteamet kan opfattes som et udtryk for negative implikationer, men erkendelse eller en opmærksomhed på disse følelser tillader individer med TBI at forholde sig til og arbejde med deres situation, hvilket er et vitalt skridt frem mod accept af deres posttraumatiske tilstand.

### ***Undersøgelsens begrænsninger***

Udvælgelsen af data søgte ikke at kontrollere variationer i deltagernes kognitive evner, og som følge deraf havde nogle af individerne i denne undersøgelse kognitive begrænsninger, der hæmmede deres evne til at udførsel af opgaverne i præ- og postsessionerne. Derfor opfattes dårlig udførelse af disse opgaver snarere som en afspejling af deres kognitive deficits end som en afspejling af beskadigelse af de variable, der undersøges her (affektiv intonation).

Gentagelsen af de same tre sange kan have begrænset genudviklingen af den vokale fleksibilitet. Introduktion af nye sange i hver session giver en kontinuerlig strøm af varierede melodilinjer, forskelle i tempo, rækkefølge af intervaller, stemning etc. Det er sandsynligt, at mere variation ville facilitere fleksibilitet i stemmelæberne. Det er derfor muligt, at den manglende variation i sangrepertoiret hindrede et maksimalt terapeutisk udbytte.

Individerne i dette studie var i en *testsituation*, hvorfor individerne muligvis har manipuleret med deres besvarelser af opgaverne i præ- og postsessionerne for bevidst eller ubevidst af påvirke resultaterne.

Andre begrænsninger i denne undersøgelse var, at individerne under udførelse af opgaverne i præ – og postsessionerne blev bedt om kunstigt at tildele en sætning en følelse. Det var på forhånd undervurderet, hvor vanskeligt denne opgave var for disse individer, specielt da de blev bedt om at intonere følelser, som de ikke oplevede i situationen. Desuden var *VAMS* for abstrakt for neurologisk beskadigede personer, på trods af at de var designet for samme. En konsekvens af dette var, at individerne scorede meget inkonsistent og med stor variation. Nogle individer rapporterede et konsistent fladt affektniveau, mens andre

rapporterede polariteter. Det er uklart, om individerne fandt opgaven for vanskelig, eller om de havde svært ved at identificere, beskrive og måle deres egen emotionelle tilstand. Som følge af de ureliable data, kan denne skala ikke anbefales til denne type forskning.

### ***Implikationer for klinisk praksis.***

Klinikere, der er interesseret i at anvende sang som intervention for patienter med TBI, og som viser beskadigelse i deres intonation, kan forvente, at der fremkommer flere typer udbytte. For det første er det sandsynligt, at der sker en forbedring af intonationsevnen, der øger klientens potentiale for en mere engageret og udtryksfuld konversation. Derfor anbefales sang som behandlingsintervention rettet mod intonationssvækkelse hos denne population.

At synge er en aktivitet, der ofte overskrider de tankemekanismer, der er påkrævet for at gennemføre andre aktiviteter. Klinikeren kan forventet et *flow* og en forøget ydeevne i klientens stemmebrug, der ikke opnås i anden sammenhæng, f.eks. gennem tonematchnings øvelser. Dette har en positiv indflydelse på disse individers dårlige *initiations evne*, og perseveration (at gentage en handling ufrivilligt), kan iagttages hos disse klienter, når de aktivt og bevidst begynder at udføre opgaver.

Klinikere kan forvente en signifikant forøgelse i stemmens rækkevidde i et kort-tids-behandlingsprogram med en forbedret intonation som “carry-over”-effekt. For at opnå dette må klinikeren udvælge sange, der giver den bedste mulighed for at øge stemmens rækkevidde og forbedre kontrol af stemmen. Klinikeren skal anvende et gradueret program, hvor register, melodisk sværhedsgrad og mængden af store intervaller i sangene anvendt i programmer stadighed øges.

Den kumulative effekt af behandlingen indikerer, at en vis tilvænningsperiode til behandlingsformen er nødvendig, før klienten kan begynde at vise udbytte af behandlingen.. Klinikere må nødvendigvis inkludere disse faktorer i forhold til længden og designet af behandlingen samt i deres evaluering af behandlingens effektivitet. Da individerne desuden generelt viser sig at klare sig bedre i præ-sessionerne sammenlignet med post-sessionerne, betragtes disse som et ikke præcist mål for vurderingen af det umiddelbare udbytte af behandlingen. Som følge af disse to forhold, bør klinikere vurdere effekten af behandlingen over tid frem for umiddelbart efter hver session.

En af grundene til, at klienterne scorer højere i præ-sessionerne frem for i post-sessionerne, forklares i dette studie ud fra det fund, at de er trætte i post-sessionerne. At deltage i terapi er trættende. Når dette kobles med klienter med TBI's prædisposition for træthed, er det påkrævet, at klinikere er opmærksom på ikke at undervurdere disse klienters tilbøjelighed til at føle træthed. Som individer i denne undersøgelse rapporterede det, blev følelsen af træthed øget i 40-50 minutter efter behandlingen. Derfor anbefales det, at klinikere overvejer kortere (og måske hyppigere) behandlingsfrekvens i arbejdet med denne population. Et alternativ hertil kunne være at tilbyde en hvileperiode, der tillader fysisk og psykisk restitution.

De fund, der viser, at der var en høj grad af variabilitet imellem de enkelte individers måde at respondere på behandlingen og deres behandlingsudbytte, har kliniske implikationer, som klinikere må overveje. Med udgangspunkt i individernes idiosynkratiske respons på behandlingen, bør klinikere være opmærksom på, at alle terapeutiske mål, metoder og strategier, der skal sikre, at klienten deltager maksimalt og med maksimalt udbytte, behøver at være individuelt tilrettelagte. Dette er specielt vigtigt da individernes kognitive svækkelse, har stor indflydelse på behandlingen.

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## APPENDICES

### 10.1 Linguistic Functions of Intonation

#### Lexical

In lexicon, intonation provides the listener with cues as to the meaning of the spoken word. In the word *object*, the second syllable rises in pitch ob (\) ject(/). But in the case of *object*, the opposite occurs ob(/) ject (\). These changes to pitch direction change the sound of the word and consequently its meaning. The significance of intonation in lexicon was assessed in a study by Glasgow (1952, cited Bolinger, 1989, p.68). It focused on the role of intonation in poetry. Subjects were asked to read poetry with either normal intonation (that is, read the text as you would normally) or with monotonal vocal pitch. The results indicated that when subjects read the poetry with a monotonal voice, there was a significant loss in word and sentence intelligibility as perceived by listeners when compared with the poetry read with normal intonation. This finding suggests that for people with brain injury who display monotonal speaking styles, there is a risk that listeners will not be able to understand the lexical meaning of their speech.

#### Syntactical

Intonation contributes to the grammar and syntax of verbal communication (Bolinger, 1986). Statements and questions represent the most extreme examples of grammatical intonation with both sentence types demonstrating opposite melodic contours. Generally, question contours rise in pitch, are raised more than those for statements, or fall less. This principle appears to underlie most of the world's languages and may be regarded as universal (Abe, 1980).

Intonation also provides the listener with grammatical cues for determining when a phrase or sentence has commenced and when it has been completed. The melodic contour of phrases follows set standard patterns, which are usually universally understood within the language of the nationality or culture being considered (Collier, 1993). Within a single phrase, the patterns often follow the form of a rising and then falling pitch pattern, where the last note of the phrase is lower than first note of the phrase.

## 10.2 Design Issues for Affective Intonation Studies

The literature reviewed was wrought with inconsistencies, probably a consequence of differing research designs. As Pittman (1994) suggests, the most reliable results are those whereby naturally occurring emotional responses were studied. However, in the laboratory, these situations cannot be captured. The research studies employed three major experimental techniques used to determine the melodic characteristics of emotionally laden speech:

1. meaningless content - having speakers express emotions while reading semantically neutral material (eg. letters from the alphabet) (Davitz & Davitz, 1959). Note that for Davitz & Davitz's (1959) study, I suggest that their use of nonsense sentences or meaningless content that requires the conscious generation of intonation may have caused their speakers to generate unnatural or inaccurate intonation patterns. Further, the choice and order of words in nonsense sentences or meaningless content may have influenced the overall intonation, this being especially true in the spoken alphabet, which is characterised by a learned rhythm.
2. constant content - comparison of the same sentence given by speakers expressing different emotions (Fairbanks & Provost, 1939; Mozziconacci & Hermes, 1997)
3. ignoring the content - either by measuring only specific nonverbal properties, or by electronically filtering the speech itself to obliterate word recognition (Apple et al., 1997; Scherer, 1991).

These major differences in design would no doubt result in different findings with regard to identifying common intonation patterns. This may be particularly true for those studies which adopted nonsense sentences where a conscious effort to convey an emotion was required. None of the studies considered asking subjects to label their mood at the time of speaking and then recording and analysing these responses. This may lead to more accurate and reliable findings with regard to affective intonation patterns.



### 10.3 Posture for Singing and Speaking

1. the head is up, face forward.
2. the chest is high, yet not rigid as in a military position of attention.
3. the highest point on the pelvis is also on the same line
4. when standing in a good posture with the feet together or slightly apart, the line from the ear and the shoulder continues through to the knee joint and in front of the ankle. The knees are not braced back rigidly
5. the natural curve of the vertebral column are preserved while it remains poised and not braced, and therefore there is minimal muscular activity. The movements of the spine are constantly and rhythmically altered in order to maintain balance.

(Bunch, 1997, p. 25)

## 10.4 Speech Pathology Research Screening Test

Subject Code:

Date:

Speech Pathologist Code:

The primary purpose of this assessment is to screen the eligibility of the subject to participate in the music therapy research. In addition, the researcher seeks information about the subject to create a detailed picture of his/her voice/vocal abilities so that each subject's music therapy intervention outcomes can be compared with other cases.

The following pages contain general information about the subject followed by Subtelny's "Speech and Diagnostic Test" (1975). Note that I have added space for you to include further information as to what you understand as being the cause of the problem. Please include information on physical limitations (such as vocal fold paralysis, poor breath control etc), and information regarding the locale of neurological damage, which could be taken from the subject's CAT or MRI results. Please consult with rehabilitation consultant if you feel this is necessary to provide an accurate picture. The more information you are able to provide, the greater the possibility for me to make comparisons between the responses of different subjects.

### Part A- Subject Information

1. Subject's age \_\_\_\_\_
2. Sex \_\_\_\_\_
3. Date of accident \_\_\_\_\_
4. Date subject was first out of PTA (please approximate if a specific date is unavailable) \_\_\_\_\_
5. Does the subject have only a moderate to minimal impairment in engaging in a normal conversation? (yes/no)
6. Does the subject only have minimal or absent impairment in articulation of words? (yes/no)
7. Is the subject able to read simple sentences? (yes/no)
8. Did the subject have any language delay/disorder or voice disorder prior to receiving the brain injury? (yes/no)
9. What is the native language of the subject \_\_\_\_\_

### Part-B: Speech and Diagnostic Test (Subtelny, 1975)

Please answer **ALL** of the following 12 sections by circling the statement that **NOW** best fits the abilities of your subject. Note that some of the sections (1,3 and 5) have an additional instruction where you are required to indicate further information with the label (+) or (-).

Also note that section 7 requires all tasks to be answered and requires the subject to be present and participate in this section of the assessment. Although not essential, it is advisable to have the subject with you whilst you complete the assessment.

#### 1. Pitch Register

Mark (+) if pitch register is above optimal level, mark (-) if pitch register is below optimal level

1. Cannot sustain phonation
2. Much above or below optimal level
3. Moderately above or below optimal level
4. Slightly above or below optimal level
5. Appropriate for age and sex

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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#### 2. Pitch Control

1. Cannot sustain phonation
2. Noticeable breaks or fluctuations of large magnitude
3. Noticeable breaks or fluctuations of small magnitude
4. Flat within limited speaking range
5. Normal satisfactory modulation of pitch

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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### 3. Loudness

If loudness is judged to be above an appropriate level mark with (+), if it is below appropriate level, mark with (-).

1. Cannot sustain audible tone
2. Much above or below appropriate level
3. Moderately above or below appropriate level
4. Slightly above or below appropriate level
5. Speech is completely intelligible

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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### 4. Loudness Control

1. Cannot sustain phonation
2. Noticeable breaks or fluctuations of large magnitude
3. Noticeable breaks or fluctuations of small magnitude
4. Flat within limited speaking range
5. Normal satisfactory modulation of intensity

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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### 5. Rate

If rate is too slow, mark with (-), if rate is too rapid, mark with (+)

1. Cannot control rate of syllable articulation
2. Much too slow/fast, rate definitely interferes with content of communication
3. Moderately below or above optimal rate
4. Slightly below optimal rate, but monitored well for clarity
5. Normal

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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**6. Control of Air Expenditure During Speech**

1. Severe problem – cannot co-ordinate respiration and phonation to sustain tone
2. Marked excess or deficiency in air expenditure
3. Moderate excess or deficiency in air expenditure
4. Slight excess or deficiency in air expenditure
5. Normal

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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**7. Breath Control**

(Record average of 3 trials)

1. Maximum duration of sustained /s/ \_\_\_\_\_ seconds
2. Maximum duration of sustained vowel sounds \_\_\_\_\_ seconds
3. Counts on one breath, number \_\_\_\_\_ “Count as far as you can on one breath” (Provide model of 3 digits per second)
4. Number of words per minute reading \_\_\_\_\_

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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**8. Prosodic Features**

*a. Blending and Stress*

1. Cannot evaluate
2. Severe Problem
3. Moderate Problem
4. Mild Problem
5. Normal

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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*b. Intonation*

1. Cannot evaluate
2. Severe Problem
3. Moderate Problem
4. Mild Problem
5. Normal

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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**9. Voice Quality**

*(a) Breathy, Weak, Lacking Clarity*

1. Voice quality varies or is too weak to judge
2. severe breathiness
3. moderate breathiness
4. mild breathiness
5. Normal quality

*(b) Tense, Harsh*

1. Vocal tension too great to sustain tone
2. Severe tenseness
3. Moderate tenseness
4. Mild tenseness
5. Normal Quality

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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**10. Nasal Resonance**

1. Resonance varies and cannot be judged
2. Severe denasality or nasality
3. Moderate denasality or nasality
4. Mild denasality or nasality
5. Normal resonance

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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### **11. Pharyngeal Resonance**

1. Resonance varies and cannot be judged
2. Marked pharyngeal resonance
3. Moderate pharyngeal resonance
4. Mild pharyngeal resonance
5. Normal resonance

Please add any additional information: type of problem, cause of problem, physical, neurological information effecting this area of ability

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### **12. Additional Comments**

Please add any additional comments regarding this subject's vocal ability that you think would be useful.

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Thankyou for completing this assessment. Would you kindly return this form to Jeanette Tamplin.

**10.5 Pitch Discrimination Answer Sheet**

| <b>Task<br/>Number</b> | <b>2<sup>nd</sup> note is<br/>Lower</b> | <b>2<sup>nd</sup> note is<br/>Higher</b> | <b>Score</b> |
|------------------------|---|--|--------------|
| <b>1</b> (sample)      | <b>X</b>                                |  |              |
| <b>2</b>               |   |  |              |
| <b>3</b>               |   |  |              |
| <b>4</b>               |   |  |              |
| <b>5</b>               |   |  |              |
| <b>6</b>               |   |  |              |
| <b>7</b>               |   |  |              |
| <b>8</b>               |   |  |              |
| <b>9</b>               |   |  |              |
| <b>10</b>              |   |  |              |
| <b>11</b>              |   |  |              |
| <b>Total</b>           |   |  |              |



## 10.6 Protocol for Pre-Selection Pitch Discrimination Task

### Step 1

Prior to the subject arriving for the test, ensure that you have selected the correct CD titled Pre-selection tests and place it in the CD player.

### Step 2

Place “do not disturb” sign on door of the treatment room.

### Step 3

Record the subject’s numerical code and the date at the top of the recording sheet.

### Step 4

On the subject’s arrival, provide him with the recording sheet and a pen (not a pencil) and a suitable table (or wheelchair tray) to write on.

### Step 5

Inform the subject that the first exercises is a listening exercise.

### Step 6

Read the client the following directions:

Please listen to the piano sounds recorded on the CD. You will hear two notes. They will be separated by a pause and then played again. You are asked to decide whether the second note is higher in pitch or lower in pitch than the first note. After you hear the two notes, mark a cross in the correct box on the form. You will see on the form that this exercise is repeated ten times. Please listen to the first example, which has been completed for you.

### Step 7

Play the first example, pause the CD and then ask the subject if he/she considers the second note to be higher or lower in pitch than the first. Check the result and check that the subject understands the exercise. Repeat the sample if necessary to ensure the exercise is understood by the subject. When he/she is clear about what to do, continue to step 8.

### Step 8

Inform the subject that you will now play the entire exercise without pausing between each item. Press play and continue until the end of the exercise.

Note: if the subject is having difficulty, please pause the CD and allow time for the client to process the material.

## 10.7 Intervals Used in the Pitch Discrimination Exercises

### Intervals used Pre-Selection

| Interval Number     | Interval                  | Pitch of 2 <sup>nd</sup> Tone |
|---------------------|---------------------------|-------------------------------|
| 1 (sample exercise) | minor 7 <sup>th</sup>     | higher                        |
| 2                   | major 6 <sup>th</sup>     | lower                         |
| 3                   | perfect 4 <sup>th</sup>   | higher                        |
| 4                   | perfect 5 <sup>th</sup>   | higher                        |
| 5                   | minor 3 <sup>rd</sup>     | higher                        |
| 6                   | minor 2 <sup>nd</sup>     | lower                         |
| 7                   | major 2 <sup>nd</sup>     | lower                         |
| 8                   | major 3 <sup>rd</sup>     | higher                        |
| 9                   | perfect 4 <sup>th</sup>   | lower                         |
| 10                  | minor 2 <sup>nd</sup>     | lower                         |
| 11                  | augmented 4 <sup>th</sup> | higher                        |

### Intervals used Post-Treatment

| Interval Number | Interval                  | Pitch of 2 <sup>nd</sup> Tone |
|-----------------|---------------------------|-------------------------------|
| 1               | minor 2 <sup>nd</sup>     | lower                         |
| 2               | minor 3 <sup>rd</sup>     | higher                        |
| 3               | perfect 4 <sup>th</sup>   | lower                         |
| 4               | minor 2 <sup>nd</sup>     | lower                         |
| 5               | major 3 <sup>rd</sup>     | higher                        |
| 6               | major 6 <sup>th</sup>     | lower                         |
| 7               | perfect 4 <sup>th</sup>   | higher                        |
| 8               | major 2 <sup>nd</sup>     | lower                         |
| 9               | perfect 5 <sup>th</sup>   | higher                        |
| 10              | augmented 4 <sup>th</sup> | higher                        |
| 11              | minor 7 <sup>th</sup>     | higher                        |

## **10.8 Protocol for the Pre-selection Test Singing Task**

### **Step 1**

Inform the subject that you will now be asking he/she to sing “Happy Birthday” first without words and then with words.

### **Step 2**

Place the microphone head set on the subject’s head and place the microphone in the correct setting.

### **Step 3**

Using the headphones, check that the subject’s voice is coming through the minidisc player - ask the subject to say something to check it is operational.

### **Step 4**

Commence the recording

### **Step 5**

Ask the subject to sing to the sound “ah”, to the tune of “Happy Birthday” and not to sing the words.

Play the guitar or piano to accompany him/her

### **Step 6**

Ask the subject to sing “Happy Birthday” again, but this time, singing the words. If the subject has difficulty remembering the words, provide him/her with a copy of the words.

Note: that you should not sing with the subject.

## **10.9 Sentences used in Intonation Discrimination Tasks**

### **Sentences used in the Pre-selection Task**

1. Then the cat came in. (happy) - SAMPLE EXERCISE
2. There is nothing in there. (angry)
3. Oh it's you. (sad)
4. What's going on? (happy)
5. It's the man next door (afraid)
6. What is in there? (afraid)
7. There is nothing in there. (sad)
8. Oh it's you. (angry)
9. What's going on? (angry)
10. It's the man next door (sad)
11. What is in there? (happy)

### **Sentences used in the Post Treatment Task**

1. It's the man next door (sad)
2. It's the man next door (afraid)
3. What's going on? (angry)
4. What is in there? (afraid)
5. Oh it's you. (angry)
6. There is nothing in there. (angry)
7. Oh it's you. (sad)
8. There is nothing in there. (sad)
9. What's going on? (happy)
10. What is in there? (happy)
11. Then the cat came in. (happy)

**10.10 Form for Pre-Selection Discrimination of Intonation Task****Subject:** \_\_\_\_\_ **Date:** \_\_\_\_\_

Procedure: You will hear a speaker say a series of sentences. Each sentence will be spoken with a different mood. These moods will be happy, sad, angry, or afraid. For each sentence, circle the response which best reflects the mood of the speaker.

1. Then the cat came in.

- ☒ a. happy
- ☐ b. sad
- ☐ c. angry
- ☐ d. afraid

2. There is nothing in there.

- ☐ a. happy
- ☐ b. sad
- ☐ c. angry
- ☐ d. afraid

3. Oh it's you.

- ☐ a. happy
- ☐ b. sad
- ☐ c. angry
- ☐ d. afraid

4. What's going on?

- a. happy
- b. sad
- c. angry
- d. afraid

5. It's the man next door

- a. happy
- b. sad
- c. angry
- d. afraid

6. What is in there?

- a. happy
- b. sad
- c. angry
- d. afraid

7. There is nothing in there.

- a. happy
- b. sad
- c. angry
- d. afraid

8. Oh it's you.

- a. happy
- b. sad
- c. angry
- d. afraid

9. What's going on?

- a. happy
- b. sad
- c. angry
- d. afraid

10. It's the man next door

- a. happy
- b. sad
- c. angry
- d. afraid

11. What is in there?

- a. happy
- b. sad
- c. angry
- d. afraid

## 10.11 Protocol for Pre-selection Pitch Discrimination Tasks

### Step 1

Inform the subject that you will ask him/her to listen to some sentences and decide what the emotion of the speaker is.

### Step 2

Record the subject's numerical code and the date at the top of the recording sheet.

### Step 3

Provide the subject with the recording sheet and a pen (not a pencil) and a suitable table (or wheelchair tray) to write on.

### Step 4

Check that the correct CD labelled Pre-selection Tests, has been placed into the CD player and cued at the correct place as indicated on the CD cover.

### Step 5

Please read the following instructions to the subject.

You will hear 11 sentences read to you by different people (some will be male voices and some will be female voices). Each of the sentences is spoken in a way that suggests a mood. For example, the person speaking may want to tell you he/she is happy through the way she speaks. Please listen carefully to the sentences and circle the correct emotion that you think the person is communicating. There will be only 4 moods to choose from: happy, sad, afraid and angry. There are 5 different sentences but each is repeated at a different point during the task in a different mood and/or spoken by a different person. Please listen to and refer to item one, which is completed for you.

### Step 6

Play the first example, pause the CD and then ask the subject what mood he/she thinks the speaker is trying to convey. Check the result and check that the subject understands the exercise. Repeat the sample if necessary to ensure the exercise is understood by the subject. When he/she is clear about what to do, continue with step 8.

### Step 7

Inform the subject that you will now play the entire exercise without pausing between each item. Press play and continue until the end of the exercise.

Note: if the subject is having difficulty, please pause the CD and allow time for the subject to process the material.



## 10.12 Introduction and Information on Research

Felicity Baker  
 Assist. Professor in Music Therapy  
 College of Higher Education  
 6823-Sandane NORWAY  
 PhD Student, Aalborg University, Denmark  
[Felicity.baker@hisf.no](mailto:Felicity.baker@hisf.no)

Tony Wigram  
 Professor in Music Therapy  
 Aalborg University  
 Denmark  
[tonywigram@hotmail.com](mailto:tonywigram@hotmail.com)  
[tony@musik.auc.dk](mailto:tony@musik.auc.dk)

Dear \_\_\_\_\_,

Date \_\_\_\_\_

I am a music therapist who was employed at Ivanhoe Manor Hospital from 1993 until 2000. I then left to take a position as Assistant Professor in Music Therapy in a University in Norway. I am currently enrolled in a Doctor of Philosophy at Aalborg University, Denmark and this involves conducting a large research project. I have decided to conduct the research here at Ivanhoe Manor and this information is an invitation for you to give consent to be part of the project.

My project aims to find out if and how song singing in a music therapy program, can improve the voice of people whose voice sounds flat and monotone following having received a brain injury. The project will assist music therapists and speech pathologists to treat people like you more effectively. Much about this area is still unknown.

The project will involve you singing 3 of your favourite songs during music therapy sessions as well as participating in short musical tests before and after each session. It is anticipated that the session (including the before and after tests) will take approximately 30-40 minutes to complete. This program will run for 15 sessions which will be held 2-3 times per week over 5-8 weeks. This program should not interfere with your normal rehabilitation program.

All information will be treated as confidential and anonymous. The findings from the research will be presented as part of a Doctoral thesis. The Ivanhoe Manor Ethics Committee has approved the project. A detailed description of the project has been formulated (see attachment) for you to examine.

Please note that you are not obliged to participate and that your decision to or not to participate will not disadvantage you or prevent you from receiving the music therapy services at a later time.

If you have any further questions you would like answered before you chose to or not to give consent to participate, please do not hesitate to contact Jeanette Tamplin at Ivanhoe Manor (94971833), or contact me directly on [felicity.baker@hisf.no](mailto:felicity.baker@hisf.no) or on +47 57 86 68 34. Please do not hesitate to contact us as we would be happy to clarify any questions you may have.

If you agree to participate in the research project, would you please sign the attached consent form and complete the questionnaire as soon as possible so that the research can commence. If you choose not to participate, I would also appreciate it if you would let Jeanette Tamplin know of your decision.

Thankyou for taking the time to read this proposal,

Felicity Baker

Assist. Professor in Music Therapy

Doctoral Candidate.

### **Music Therapy programs to Rehabilitate Speaking Intonation**

**Chief Researcher:** Tony Wigram, Professor in Music Therapy, Aalborg University, Denmark

**Associate Researcher:** Felicity Baker, PhD student Aalborg University, Assist. Professor, College in Sogn og Fjordane, Faculty of Higher Education.

**Music Therapy Clinician:** Jeanette Tamplin, Registered Music Therapist, Ivanhoe Manor Private Rehabilitation Hospital

This project studies the effect of song singing on the improvements in vocal intonation of people who have limited vocal intonation following brain injury.

**Main Aim:** To establish if and then understand why music therapy helps people with voice problems (speaking intonation) improve in the range of voice intonation and vocal expressiveness.

People who fit the following criteria will be invited to participate:

- Has a brain injury
- Demonstrate restricted intonation patterns
- are between 18 and 65 years of age,
- speak Australian English
- demonstrates normal or minimal difficulties in articulating verbal communication and is able to interact in a basic conversation.
- has no difficulty initiating voice.
- is able to read simple sentences.
- has no known history of a language delay/disorder or voice disorder prior to receiving the brain injury.
- demonstrates minimal or no difficulty in auditory discrimination tasks scoring correctly
- is able to sing “Happy Birthday”

As this study is exploratory, and given the infrequent occurrence of this disorder, multiple case study design was selected and 5 cases was considered adequate to determine trends and outcomes.

If you consent to participating in this project, you will receive a total of 15 music therapy sessions (2-3 per week, for 5-8 weeks). Each session will be between 30-40 minutes in duration. During each session, you will be asked to complete a series of small music exercises which should take about 10 minutes. Please understand that these tests are not meant to determine if you are musical or not, but are there to determine whether there has been a change in your ability to use pitch while you speak. In addition, you will be asked to complete a short mood test which will tell the researcher what mood you were in when you were participating in the research. After these short exercises, you will sing 3 of your favourite songs together with the music therapist. After this, you will again be asked to complete the same tests you completed before you sang the three songs.

During the sessions, you will be video taped and also your voice will be taped onto a minidisc player using a microphone placed on your head. Both the video and minidisc recordings will be used to see what changes you have made. All this information will be confidential, and all identifying material will be removed. It is possible that the video of you may be used in conference presentations to demonstrate to others, your (and others) participation in the song singing activities. Further, your results may be published in professional journals, however, your name and identifying material will not be included, you will remain totally anonymous. The records of your participation will be kept locked in a filing cabinet and the computerised information stored on a cd-rom which will also be kept locked in a filing cabinet. The records will be shredded after 5 years.

If you agree to participate in the program, you will not miss any of your other therapy sessions, nor will this mean you cannot have music therapy after you have finished the research program. You may withdraw from the research project at any time, but once you have withdrawn, you will be unable to recommence participation. If you miss any of the sessions, you will be unable to further participate in the research.

The results of the study will be submitted as part of a Doctoral thesis which will be submitted in 2005-2006.

There is no expected physical discomfort or risks associated with the research project. If you experience any voice soreness or hoarseness, then the music therapy program will

immediately cease and you will be withdrawn from the project. However, I anticipate that this situation is very unlikely.

The positive benefits from the program may be that:

1. you will have another enjoyable activity to fill your day up with
2. you will obtain a greater vocal range which may mean that your voice will sound less flat and more interesting to the listener and you will have your message communicated to others more accurately.
3. You may feel more physically relaxed following the music
4. Your mood may improve, you may feel happier after the music
5. It may help your brain to recover lost function

I hope if you agree to participate in the study you will find it enjoyable. However, you are not obliged to participate and you are free to withdraw from the study at any time.

If you agree to participate, please complete the attached consent form and music questionnaire and return it to Jeanette Tamplin. Also included is a questionnaire for your family to complete. If requested, I can prepare a statement of the results of your participation in the study.

### 10.13 Consent Form

Researcher: Felicity Baker, M.Mus, RMT  
Assist. Professor in Music Therapy  
College of Higher Education  
6823 Sandane  
NORWAY  
felicity.baker@hisf.no

**Title of the research project:** Music Therapy programs to Rehabilitate Speaking Intonation

I \_\_\_\_\_, of \_\_\_\_\_  
(Address) \_\_\_\_\_

agree to take part in the research project described in the attached explanation, being conducted by Felicity Baker (in collaboration with Jeanette Tamplin). I have had the research fully explained to me and given a copy of the explanatory statement. I acknowledge that I shall participate in 15 sessions of music therapy, 2-3 sessions per week and it is important that I participate in all the sessions at the scheduled time and only be absent from these sessions in extreme circumstances. However, I understand that I am free to withdraw from the research project at anytime but once I have withdrawn I will be unable to recommence participation at a later date. I also agree to being video taped and my voice being recorded on a minidisc recorder so that it can be later analysed. I understand that all identifying information (name, age, address, circumstances etc) will be omitted from the data, and that I will be identified by a numerical code only.

Signature \_\_\_\_\_ Date: \_\_\_\_\_

Address: \_\_\_\_\_

I \_\_\_\_\_ also agree that the video be available for viewing by other researchers and used in conference presentations.

Signature \_\_\_\_\_ Date: \_\_\_\_\_

I \_\_\_\_\_ (independent witness) witness that the above consent has been given freely after due explanation of procedures, and that the consent has been given quite freely.

Signed \_\_\_\_\_ Date: \_\_\_\_\_

## 10.14 Family Questionnaire

The information sought in this questionnaire will be helpful to the researcher by allowing her to draw conclusions regarding the changes and reasons for these changes in \_\_\_\_\_ voice following participation in music therapy. It would be appreciated if you would answer all of these questions as best you can. Please ask Jeanette Tamplin for assistance if you would like it.

1. Can you describe \_\_\_\_\_ voice before receiving the injury: (for example: high pitched, low pitched, loud, soft, harsh, gentle, gravelly, sing song, accented, shriek, shrill, nasally, gurgly)

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2. Can you describe \_\_\_\_\_ voice before as it sounds to you now: (for example: high pitched, low pitched, loud, soft, harsh, gentle, gravelly, sing song, accented, shriek, shrill, nasally, gurgly)

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3. Can you mark on the two lines below, how expressive you think \_\_\_\_\_ voice is before the accident and now:

### Before Injury

Monotone \_\_\_\_\_  
(no pitch change  
during talking)

Very expressive  
and dynamic  
(large, frequent  
changes in pitch)

### After the Injury

Monotone \_\_\_\_\_  
(no pitch change  
during talking)

Very expressive  
and dynamic  
(large, frequent  
changes in pitch)

4. Do you have a video of \_\_\_\_\_ talking, or an audio recording of \_\_\_\_\_ voice which the researcher could borrow so that changes in voice can be clearly illustrated and to also compare the outcomes of the program: \_\_\_\_\_. If yes, can you please loan this to the researcher. Please note that the video will be returned.

### 10.15 Musical Background Questionnaire

Subject Code: \_\_\_\_\_

(1). How would you rate the importance of music in your life?

Not important                      Important                      Very important                      Essential

(2). Did you ever play a musical instrument(s)?                      Yes                      No

If you answered yes, which instrument did you play and for how many years did you play this instrument(s)?

(3). How much music would you have listened to per week, prior to your accident occurring?

1 hour                      2 hours                      3 hours                      4 hours                      5+ hours

(4). Have you ever sung in choirs, musicals, or operas either as a part of a group or as a solo artist? \_\_\_\_\_

If yes, what style of music was used: rock, pop, choral, opera, gospel, Jazz, musicals, other (please specify)\_\_\_\_\_.

(5). Please list in the space provided below the names of any particular songs, bands and/or solo artists that you frequently listened to. Please also indicate whether a cassette tape or compact disc could be loaned to the music therapist for the purposes of this research.

Please tick if able to loan a recording to the music therapist

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.



## 10.16 Intervals Use for Each Session

### Session 1, 6, 11

| Interval Number | Interval Size             | Pitch of 2 <sup>nd</sup> Tone |
|-----------------|---------------------------|-------------------------------|
| 1               | major 3 <sup>rd</sup>     | Lower                         |
| 2               | major 6 <sup>th</sup>     | Higher                        |
| 3               | perfect 4 <sup>th</sup>   | Lower                         |
| 4               | minor 3 <sup>rd</sup>     | Higher                        |
| 5               | minor 2 <sup>nd</sup>     | Lower                         |
| 6               | perfect 5 <sup>th</sup>   | Higher                        |
| 7               | major 2 <sup>nd</sup>     | Higher                        |
| 8               | augmented 4 <sup>th</sup> | Lower                         |
| 9               | minor 6 <sup>th</sup>     | Higher                        |
| 10              | minor 7 <sup>th</sup>     | Lower                         |

### Session 2, 7, 12

| Interval Number | Interval Size             | Pitch of 2 <sup>nd</sup> Tone |
|-----------------|---------------------------|-------------------------------|
| 1               | major 3 <sup>rd</sup>     | Higher                        |
| 2               | major 6 <sup>th</sup>     | Lower                         |
| 3               | perfect 4 <sup>th</sup>   | Higher                        |
| 4               | minor 3 <sup>rd</sup>     | Lower                         |
| 5               | minor 2 <sup>nd</sup>     | Higher                        |
| 6               | perfect 5 <sup>th</sup>   | Lower                         |
| 7               | major 2 <sup>nd</sup>     | Lower                         |
| 8               | augmented 4 <sup>th</sup> | Higher                        |
| 9               | minor 6 <sup>th</sup>     | Lower                         |
| 10              | minor 7 <sup>th</sup>     | Higher                        |

### Session 3, 8, 13

| Interval Number | Interval Size             | Pitch of 2 <sup>nd</sup> Tone |
|-----------------|---------------------------|-------------------------------|
| 1               | minor 7 <sup>th</sup>     | Lower                         |
| 2               | minor 6 <sup>th</sup>     | Higher                        |
| 3               | augmented 4 <sup>th</sup> | Lower                         |
| 4               | major 2 <sup>nd</sup>     | Higher                        |
| 5               | perfect 5 <sup>th</sup>   | Lower                         |
| 6               | minor 2 <sup>nd</sup>     | Higher                        |
| 7               | minor 3 <sup>rd</sup>     | Higher                        |
| 8               | perfect 4 <sup>th</sup>   | Lower                         |
| 9               | major 6 <sup>th</sup>     | Higher                        |
| 10              | major 3 <sup>rd</sup>     | Lower                         |

**Session 4, 9, 14**

| <b>Interval Number</b> | <b>Interval Size</b>      | <b>Pitch of 2<sup>nd</sup> Tone</b> |
|------------------------|---------------------------|-------------------------------------|
| <b>1</b>               | minor 7 <sup>th</sup>     | Higher                              |
| <b>2</b>               | minor 6 <sup>th</sup>     | Lower                               |
| <b>3</b>               | augmented 4 <sup>th</sup> | Higher                              |
| <b>4</b>               | major 2 <sup>nd</sup>     | Lower                               |
| <b>5</b>               | perfect 5 <sup>th</sup>   | Higher                              |
| <b>6</b>               | minor 2 <sup>nd</sup>     | Lower                               |
| <b>7</b>               | minor 3 <sup>rd</sup>     | Lower                               |
| <b>8</b>               | perfect 4 <sup>th</sup>   | Higher                              |
| <b>9</b>               | major 6 <sup>th</sup>     | Lower                               |
| <b>10</b>              | major 3 <sup>rd</sup>     | Higher                              |

**Session 5, 10, 15**

| <b>Interval Number</b> | <b>Interval Size</b>      | <b>Pitch of 2<sup>nd</sup> Tone</b> |
|------------------------|---------------------------|-------------------------------------|
| <b>1</b>               | minor 2 <sup>nd</sup>     | Lower                               |
| <b>2</b>               | minor 3 <sup>rd</sup>     | Higher                              |
| <b>3</b>               | perfect 4 <sup>th</sup>   | Lower                               |
| <b>4</b>               | major 6 <sup>th</sup>     | Higher                              |
| <b>5</b>               | major 3 <sup>rd</sup>     | Lower                               |
| <b>6</b>               | minor 7 <sup>th</sup>     | Higher                              |
| <b>7</b>               | minor 6 <sup>th</sup>     | Higher                              |
| <b>8</b>               | augmented 4 <sup>th</sup> | Lower                               |
| <b>9</b>               | major 2 <sup>nd</sup>     | Higher                              |
| <b>10</b>              | perfect 5 <sup>th</sup>   | Lower                               |

### **10.17 Visual Analog Mood Scale**

Please refer to the booklet inserted in this thesis.

### 10.18 Validity of VAMS

Stern et al. (1997) conducted two studies with normal population. The first compared VAMS with Profile Mood Scale (POMS)<sup>1</sup>. Convergent validity was supported by the finding that the correlations between the corresponding scales of the two methods were large relative to the correlations between the non-corresponding scales of the two methods (monotrait-heteromethod;  $p < .001$ ). Discriminant validity was supported by the finding that the correlations between each of the VAMS scales and non-corresponding POMS scales were small and the remaining VAMS scales were also small. The second study found similar findings when the VAMS was compared with the Beck Depression Inventory<sup>2</sup> (monotrait-heteromethod,  $p < .01$ ). The Pearson correlation coefficients were calculated between each of the VAMS scales and the BDI showing that VAMS demonstrated good convergent validity.

Nyenhuis et al. (1996) compared the VAMS with POMS, BDI and the State-Trait Anxiety Inventory. Strong findings were again reported.

With regard to stroke subjects, Arruda et al. (1997) compared VAMS with POMS. Results again indicated good to excellent convergent and discriminant validity. A significant effect for trait was found ( $p < .01$ ) indicating that correlations between corresponding scales of the two methods (monotrait-heteromethod) significantly differ from zero and were large relative to those correlations found between non-corresponding scales of the two methods. Convergent validity was supported by the finding that the correlation coefficients between the VAMS and POMS scales were high (monotrait-heteromethod;  $p < .01$ ). Discriminant validity was supported by the finding that the correlations between each of the VAMS scales and non-corresponding POMS scales were low, and the remaining VAMS scales were also low.

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<sup>1</sup> The POMS is a 65 item adjective checklist with established psychometric properties and measures six mood states: depression-dejection, tension-anxiety, anger-hostility, vigor, fatigue and confusion.

<sup>2</sup> Beck Depression Inventory is a 21 item, self report measure of depressive symptoms.

## 10.19 Post-Treatment Subject Questionnaire

Subject Code\_\_\_\_\_

Date\_\_\_\_\_

Please think about your voice and your ability to communicate and talk with others, and place a mark on the scale below, your response to the following questions.

1. Have you noticed any changes in the use of your voice from before and after participating in music therapy?

My voice appears:

|                  |                   |              |                      |                     |        |
|------------------|-------------------|--------------|----------------------|---------------------|--------|
|                  |                   |              |                      |                     |        |
| Notably<br>worse | Slightly<br>worse | No<br>change | Slightly<br>improved | Notably<br>improved | Unsure |

2. have you noticed any changes in your ability to express emphasis in your voice?

|                  |                   |              |                      |                     |        |
|------------------|-------------------|--------------|----------------------|---------------------|--------|
|                  |                   |              |                      |                     |        |
| Notably<br>worse | Slightly<br>worse | No<br>change | Slightly<br>improved | Notably<br>improved | Unsure |

3. have you noticed any changes in your ability to be emotionally expressive with your voice?

|                  |                   |              |                      |                     |        |
|------------------|-------------------|--------------|----------------------|---------------------|--------|
|                  |                   |              |                      |                     |        |
| Notably<br>worse | Slightly<br>worse | No<br>change | Slightly<br>improved | Notably<br>improved | Unsure |

## 10.20 Transformation of variables

1. Formula for SVS:

$$SVS = \log_{\sqrt[12]{2}} \left( \frac{F_0 + SD(F_0)}{F_0} \right)$$

2. Formula for slope:

$$slope = \frac{\log_{\sqrt[12]{2}}(F_{higher} / F_{lower})}{time}$$

3. Formula for melodic pitch deviation:

$$ST = \left| \log_{\sqrt[12]{2}} \frac{F_{obs}}{F_{tgt}} \right|$$

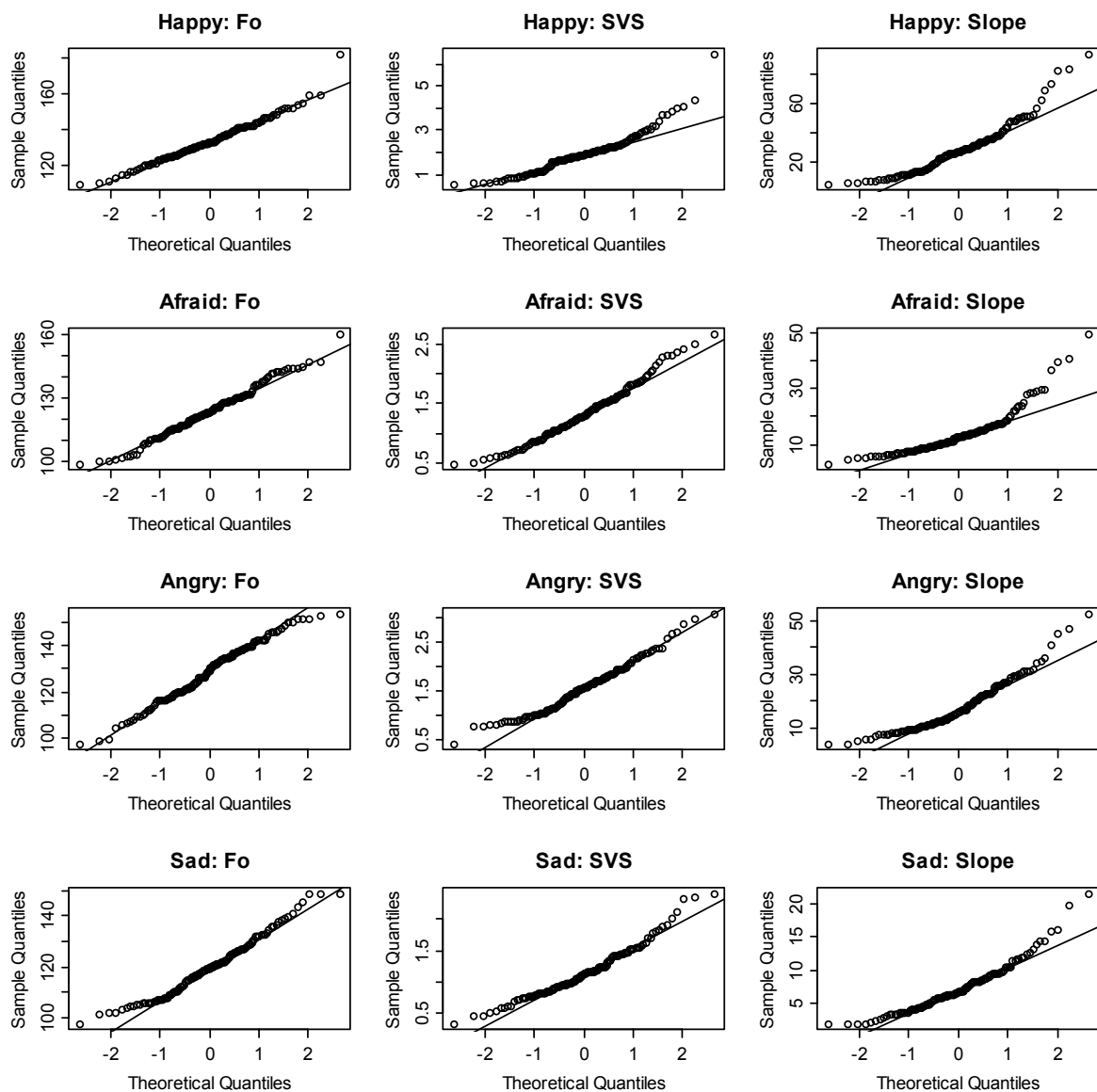
where ST is the absolute difference in semitones,  $F_{obs}$  the observed frequency, and  $F_{tgt}$  the target frequency.

## 10.21 Data Screening – Sentence Data

The following graphs show the distributions of values of different variables, plotted against a normal distribution. If the distribution of the variable approximates a normal distribution, the values are expected to lie close to the line. In cases of gross deviations, the following possibilities were considered:

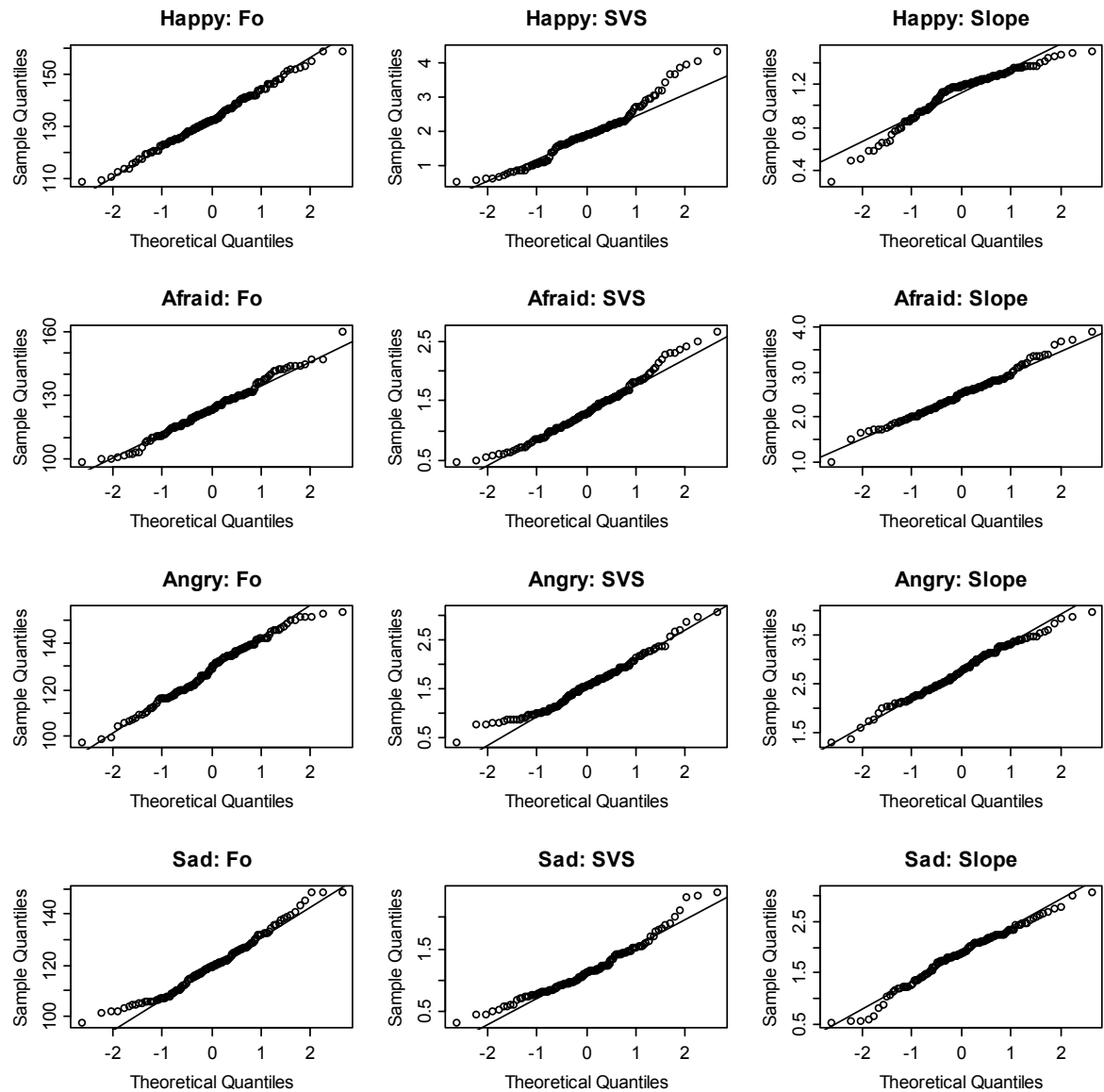
- A single value that is clearly different from the rest: This may indicate false measurement, and exclusion of the value may be justified.
- A systematic deviation: This may indicate a non-normal distribution that may be transformed into a normal distribution (with a logarithmic, quadratic, etc. transformation).
- A systematic deviation that cannot be transformed appropriately: Robust statistical methods should be used.

### 1. Original data, unmodified:



These data show an outlying value each in the Fo and SVS of the "happy" sentence. The highest value of each of these two variables was excluded. The slope data of all four sentences show a systematic deviation. The natural logarithm of the slope was used. The results are shown in the following graph.

## 2. After transformation and exclusion of values:

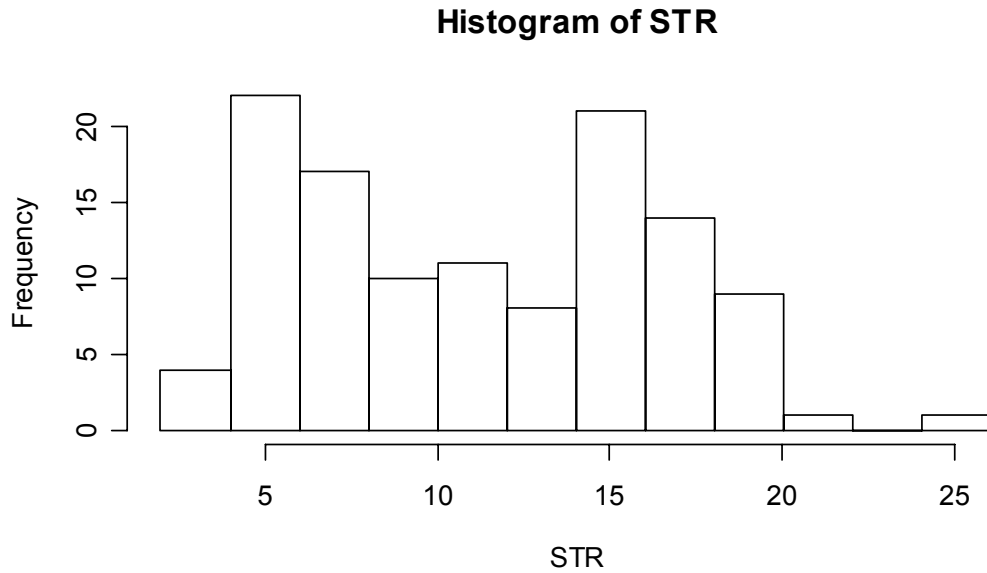


These data approximate normal distributions.



## 10.22 Data Screening – Voice Range

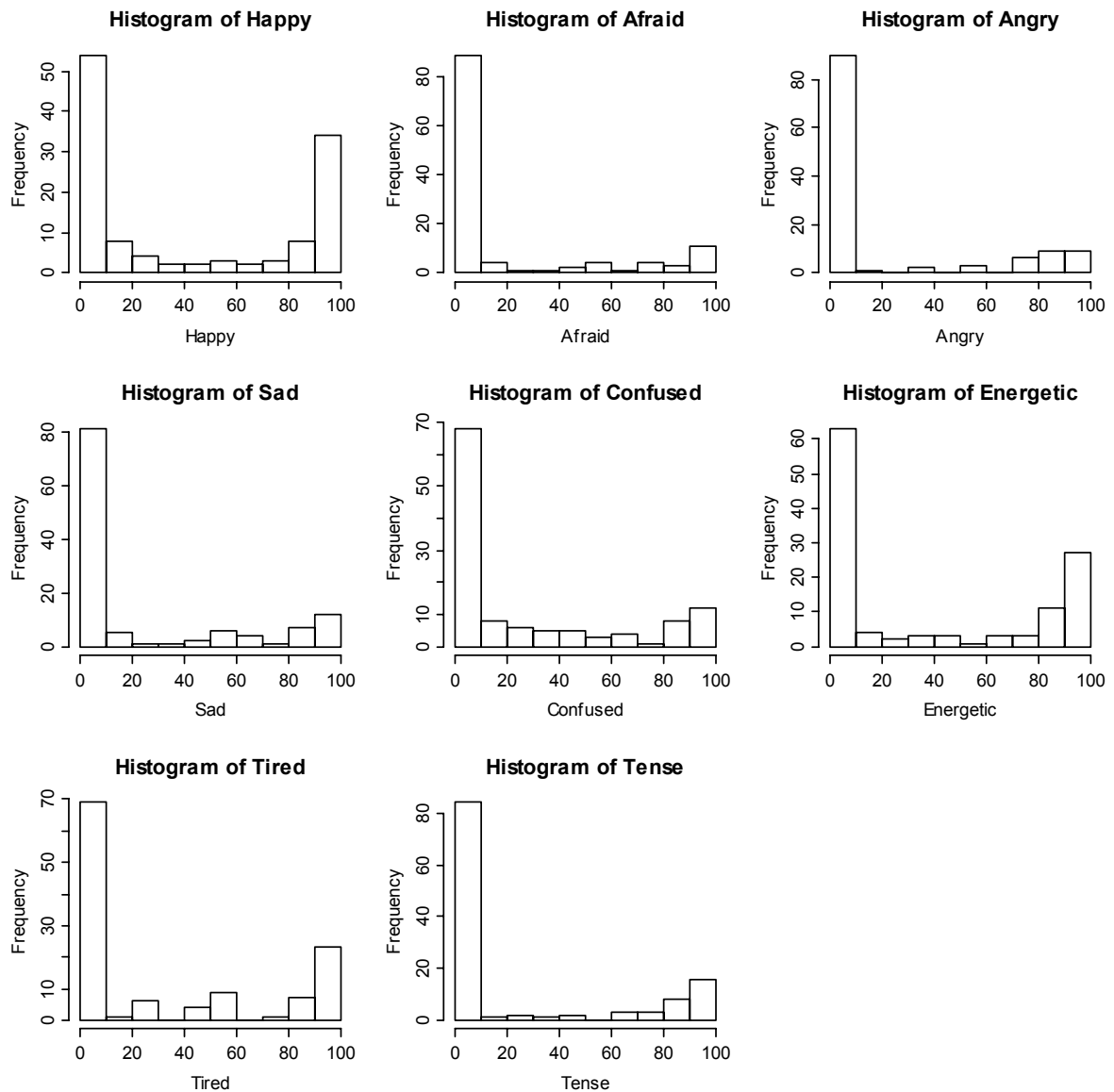
The following graph shows the distribution of values for the subjects' maximum semitone range.



The graph shows a continuous distribution with two peaks, but without any obvious skewness or extreme outliers.

### 10.23 Data Screening for Visual analogue Mood scales

The following histograms show the distributions of Mood data.

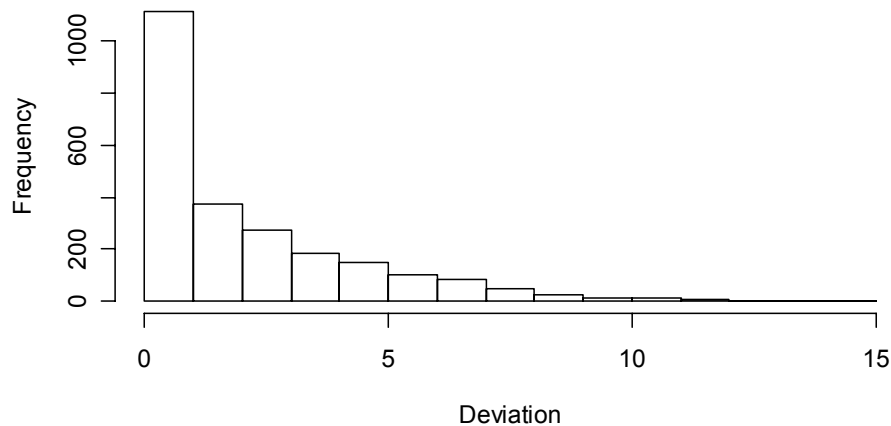


This shows that subjects were more likely to mark one of the extreme positions on the scale, rather than using the whole spectrum. These extreme two-peak distributions could not be corrected with a transformation.

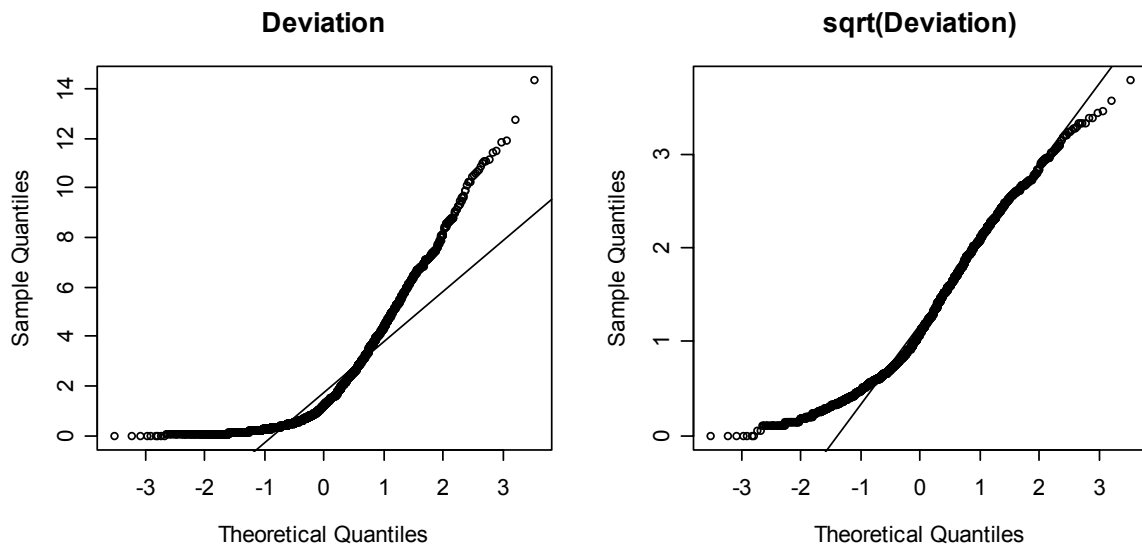
## 10.24 Data Screening Pitch Matching in Exercises

The pitch matching data represent the deviation from the target frequency in either direction, i.e. omitting the sign. Therefore, instead of the bell curve of a normal distribution, a half bell curve of a normal distribution that is folded along the y-axis was expected.

The distribution is shown below.



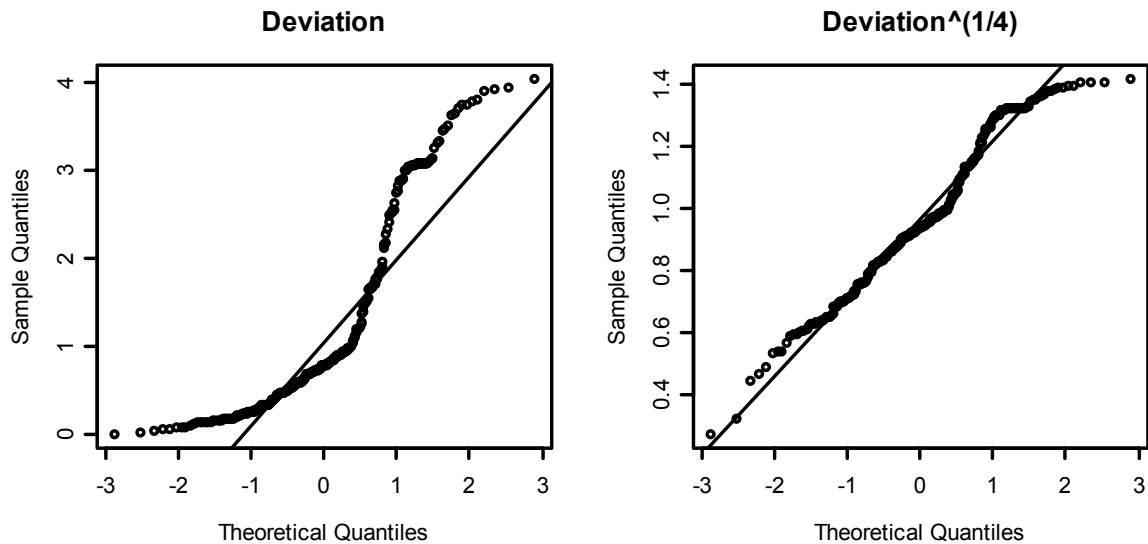
To correct this skewed distribution, the square root of the variable was used (see the following figure).



This figure shows that the square root of the Deviation has a less skewed distribution and approximates a normal distribution.

### 10.25 Data Screening - Pitch Matching in Songs

The following graph shows the deviations from target intervals within songs in their original form and with a transformation.



This figure shows that the 4<sup>th</sup> root of the deviation was much closer to a normal distribution than the original data.

## 10.26 Effect sizes for all pooled data

### Intonation Data

| <i>Outcome</i>      | <i>Long-term (Session 1 vs. session 15)</i> |          |              |              |          |           |          | <i>Immediate (Pre-session vs. post-session)</i> |          |              |              |          |           |          |
|---------------------|---|----------|--------------|--------------|----------|-----------|----------|---|----------|--------------|--------------|----------|-----------|----------|
|                     | <i>n</i>                                    | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> | <i>n</i>  | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> |
| <i>T.Fo</i>         | 64  | 0.31     | 0.06         | 0.56         | 2.50     | 63        | 0.02     | 237   | -0.16    | -0.25        | -0.07        | -3.47    | 236       | 0.00     |
| <i>Fo.Happy</i>     | 16  | 0.18     | -0.56        | 0.91         | 0.51     | 15        | 0.62     | 60  | -0.29    | -0.53        | -0.05        | -2.44    | 59        | 0.02     |
| <i>Fo.Afraid</i>    | 16  | 0.30     | -0.23        | 0.84         | 1.21     | 15        | 0.25     | 59  | -0.18    | -0.41        | 0.04         | -1.66    | 58        | 0.10     |
| <i>Fo.Angry</i>     | 16  | 0.51     | 0.04         | 0.97         | 2.33     | 15        | 0.03     | 59  | -0.04    | -0.19        | 0.11         | -0.50    | 58        | 0.62     |
| <i>Fo.Sad</i>       | 16  | 0.45     | -0.23        | 1.12         | 1.41     | 15        | 0.18     | 59  | -0.20    | -0.38        | -0.01        | -2.10    | 58        | 0.04     |
| <i>T.SVS</i>        | 64  | -0.15    | -0.36        | 0.06         | -1.47    | 63        | 0.15     | 237   | -0.02    | -0.12        | 0.08         | -0.38    | 236       | 0.70     |
| <i>SVS.Happy</i>    | 16  | -0.26    | -0.64        | 0.13         | -1.44    | 15        | 0.17     | 60  | -0.09    | -0.30        | 0.13         | -0.80    | 59        | 0.43     |
| <i>SVS.Afraid</i>   | 16  | -0.37    | -1.05        | 0.30         | -1.19    | 15        | 0.25     | 59  | -0.15    | -0.40        | 0.10         | -1.21    | 58        | 0.23     |
| <i>SVS.Angry</i>    | 16  | 0.06     | -0.52        | 0.65         | 0.23     | 15        | 0.82     | 59  | 0.08     | -0.16        | 0.33         | 0.68     | 58        | 0.50     |
| <i>SVS.Sad</i>      | 16  | -0.10    | -0.82        | 0.62         | -0.29    | 15        | 0.77     | 59  | 0.16     | -0.07        | 0.38         | 1.40     | 58        | 0.17     |
| <i>T.Slope</i>      | 62  | -0.10    | -0.33        | 0.13         | -0.86    | 61        | 0.39     | 222   | -0.05    | -0.15        | 0.05         | -1.05    | 221       | 0.29     |
| <i>Slope.Happy</i>  | 16  | -0.06    | -0.62        | 0.49         | -0.24    | 15        | 0.82     | 56  | -0.19    | -0.43        | 0.05         | -1.60    | 55        | 0.12     |
| <i>Slope.Afraid</i> | 16  | -0.58    | -1.24        | 0.08         | -1.88    | 15        | 0.08     | 56  | -0.05    | -0.38        | 0.27         | -0.32    | 55        | 0.75     |
| <i>Slope.Angry</i>  | 16  | 0.16     | -0.36        | 0.68         | 0.66     | 15        | 0.52     | 56  | 0.10     | -0.15        | 0.36         | 0.82     | 55        | 0.42     |
| <i>Slope.Sad</i>    | 14  | -0.23    | -0.84        | 0.38         | -0.83    | 13        | 0.42     | 54  | -0.01    | -0.31        | 0.30         | -0.04    | 53        | 0.97     |

### Voice Range Data

| <i>Outcome</i> | <i>Long-term (Session 1 vs. session 15)</i> |          |              |              |          |           |          | <i>Immediate (Pre-session vs. post-session)</i> |          |              |              |          |           |          |
|----------------|---|----------|--------------|--------------|----------|-----------|----------|---|----------|--------------|--------------|----------|-----------|----------|
|                | <i>n</i>                                    | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> | <i>n</i>  | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> |
| <i>V.Range</i> | 15  | 0.33     | 0.03         | 0.64         | 2.33     | 14        | 0.04     | 58  | -0.09    | -0.24        | 0.07         | -1.13    | 57        | 0.26     |

**Pitch Matching Exercise Data**

| <i>Outcome</i> | <i>Long-term (Session 1 vs. session 15)</i> |          |              |              |          |           |          | <i>Immediate (Pre-session vs. post-session)</i> |          |              |              |          |           |          |
|----------------|---|----------|--------------|--------------|----------|-----------|----------|---|----------|--------------|--------------|----------|-----------|----------|
|                | <i>n</i>                                    | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> | <i>n</i>  | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> |
| <i>T.Pitch</i> | 312   | -0.08    | -0.22        | 0.06         | -1.10    | 311       | 0.27     | 1185  | -0.03    | -0.08        | 0.02         | -1.07    | 1184      | 0.29     |
| <i>min.2nd</i> | 32  | -0.19    | -0.55        | 0.17         | -1.10    | 31        | 0.28     | 118   | -0.08    | -0.25        | 0.10         | -0.83    | 117       | 0.41     |
| <i>Maj.2nd</i> | 29  | -0.11    | -0.50        | 0.29         | -0.54    | 28        | 0.59     | 116   | -0.07    | -0.26        | 0.13         | -0.67    | 115       | 0.50     |
| <i>min.3rd</i> | 32  | 0.32     | -0.35        | 0.99         | 0.96     | 31        | 0.34     | 120   | 0.07     | -0.09        | 0.23         | 0.84     | 119       | 0.40     |
| <i>Maj.3rd</i> | 32  | 0.95     | 0.09         | 1.80         | 2.26     | 31        | 0.03     | 119   | 0.06     | -0.09        | 0.21         | 0.83     | 118       | 0.41     |
| <i>P.4th</i>   | 32  | 0.81     | 0.00         | 1.62         | 2.03     | 31        | 0.05     | 119   | -0.05    | -0.17        | 0.07         | -0.80    | 118       | 0.42     |
| <i>Aug.4th</i> | 29  | -0.10    | -0.59        | 0.39         | -0.41    | 28        | 0.68     | 117   | 0.00     | -0.17        | 0.17         | -0.02    | 116       | 0.98     |
| <i>P.5th</i>   | 32  | -0.23    | -0.62        | 0.16         | -1.20    | 31        | 0.24     | 119   | -0.18    | -0.36        | -0.01        | -2.05    | 118       | 0.04     |
| <i>min.6th</i> | 30  | -0.21    | -0.69        | 0.27         | -0.88    | 29        | 0.38     | 117   | 0.04     | -0.10        | 0.17         | 0.53     | 116       | 0.60     |
| <i>Maj.6th</i> | 32  | -0.17    | -0.65        | 0.32         | -0.71    | 31        | 0.48     | 120   | 0.01     | -0.13        | 0.14         | 0.09     | 119       | 0.93     |
| <i>min.7th</i> | 32  | -0.61    | -1.00        | -0.21        | -3.13    | 31        | 0.00     | 120   | -0.04    | -0.20        | 0.11         | -0.58    | 119       | 0.57     |

**Mood Scale Data**

| <i>Outcome</i>     | <i>Long-term (Session 1 vs. session 15)</i> |          |              |              |          |           |          | <i>Immediate (Pre-session vs. post-session)</i> |          |              |              |          |           |          |
|--------------------|---|----------|--------------|--------------|----------|-----------|----------|---|----------|--------------|--------------|----------|-----------|----------|
|                    | <i>n</i>                                    | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> | <i>n</i>  | <i>d</i> | <i>CI(L)</i> | <i>CI(U)</i> | <i>t</i> | <i>df</i> | <i>p</i> |
| <i>M.Happy</i>     | 16  | 0.20     | -0.42        | 0.82         | 0.68     | 15        | 0.51     | 60  | 0.01     | -0.15        | 0.18         | 0.13     | 59        | 0.90     |
| <i>M.Afraid</i>    | 16  | -0.22    | -1.02        | 0.57         | -0.60    | 15        | 0.56     | 60  | 0.14     | -0.04        | 0.32         | 1.57     | 59        | 0.12     |
| <i>M.Angry</i>     | 16  | 0.02     | -0.72        | 0.75         | 0.05     | 15        | 0.96     | 60  | 0.14     | -0.05        | 0.33         | 1.46     | 59        | 0.15     |
| <i>M.Sad</i>       | 16  | -0.25    | -0.81        | 0.31         | -0.94    | 15        | 0.36     | 60  | 0.12     | -0.07        | 0.31         | 1.25     | 59        | 0.21     |
| <i>M.Confused</i>  | 16  | -0.24    | -0.82        | 0.34         | -0.87    | 15        | 0.40     | 60  | 0.05     | -0.13        | 0.23         | 0.55     | 59        | 0.58     |
| <i>M.Energetic</i> | 16  | 0.09     | -0.40        | 0.58         | 0.40     | 15        | 0.70     | 60  | 0.09     | -0.13        | 0.31         | 0.79     | 59        | 0.43     |
| <i>M.Tired</i>     | 16  | 0.19     | -0.42        | 0.80         | 0.66     | 15        | 0.52     | 60  | 0.12     | -0.07        | 0.32         | 1.26     | 59        | 0.21     |
| <i>M.Tense</i>     | 16  | -0.43    | -0.94        | 0.08         | -1.79    | 15        | 0.09     | 60  | -0.07    | -0.23        | 0.09         | -0.83    | 59        | 0.41     |